The Blast Furnace and Steel Plant

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CONTENTS

VOL. IX. OCTOBER, 1921 No. 10

Page

NEW BLAST FURNACE OF THE CRANE IRON WORKS MODERNIZES PLANT AT CATASAUQUA, PA.—By Richard Peters, Jr. 577

RECENT IMPROVEMENTS IN THE MANUFACTURE OF WELDED PIPE—By F. N. Speller 580

THE LOGIC OF ROLL DESIGN—By W. H. Melaney 583

GAS PRODUCERS FOR BITUMINOUS COAL—By Henry William Seldon 586

NEW 600-TON BLAST FURNACE PLANT 588

STEEL PLANT ELECTRICAL ENGINEERS CONVENTION 598

ANTI-FRICTION BEARINGS IN THE STEEL MILL—By A. M. MacCutcheon 600

WASTE HEAT UTILIZATION FOR STEAM GENERATION—By G. R. McDermott 607

ELECTRIFICATION OF THE STEEL PLANT RAILROAD—By R. B. Gerhardt 613

ELECTRIC DRIVE FOR SMALL AUTOMATIC SELF-DUMPING SKIP HOISTS—By R. M. McLain and C. B. Connely 617

DAMASCENE STEEL AND ITS ORIGIN—By Colonel N. T. Belaiew, C. B. 621

BOILER WATER TREATMENT PLANTS—By Robert June 623

PRODUCTION TOPICS 626

WITH THE EQUIPMENT MANUFACTURERS 627

NEWS OF THE PLANTS 628

OPEN HEARTH 629

SOME POINTERS ON BY-PRODUCT COKE OVENS 631

TRADE NOTES, TRADE PUBLICATIONS 632

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The Blast Furnace and Steel Plant

VOL. IX. PITTSBURGH, PA., OCTOBER, 1921 No. 10

New Blast Furnace of the Crane Iron Works Modernizes Plant at Catasauqua, Pa.

The First of a Series of Articles Describing Several Eastern Blast Furnace Plants, Which Were Pioneers in the Pig Iron Industry, and Which Have Recently Been Rebuilt to Conform with Modern Practice.

By RICHARD PETERS, Jr.,
Manager of Sales, Pulaski Iron Co.

TOWARD the close of our Civil War, John Percy of the Royal School of Mines of London gave to the iron making world his monumental work on the metallurgy of iron and steel, which for more than a generation was the leading authority on the subject which he presented. In the author's commentaries on the iron making establishments in countries other than his own, he dwells at length on the subject of the anthracite furnaces in the United States, concluding his remarks with the statement that "the principal manufacture must always cling to the Lehigh and Schuylkill and Lower Susquehanna valleys in Pennsylvania, where the ore is abundant, the coal near at hand, the flux on the spot, where the whole land is a garden and therefore food cheap and labor plentiful and the great sea ports not far off."

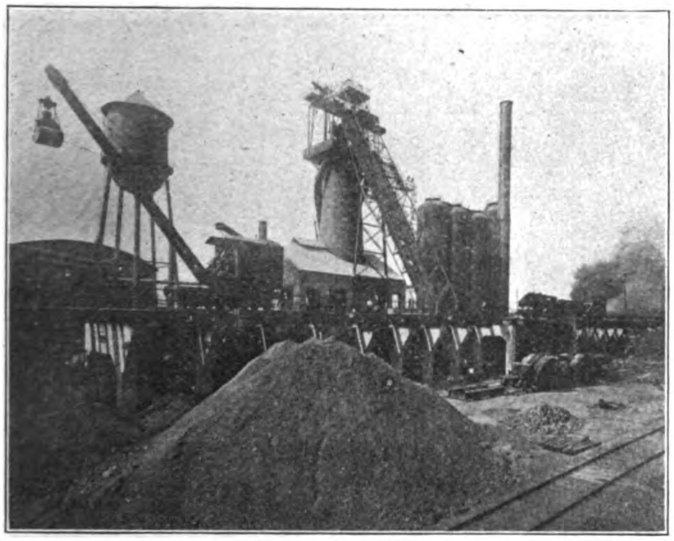

Fig. 1—General view showing the furnace, skip bridge, trestle, etc.

To a certain degree this prophecy of some 60 years ago has been fulfilled, although the changes brought forth by time and new methods have modified, to some extent, the broad assertions the author made in his work. Of the districts mentioned by Percy, the Lehigh valley has more nearly survived its promise, and while the anthracite coal used originally as fuel has been almost entirely replaced by coke from the western part of the state, and the local brown ores have given way to the Lake Superior hematites, yet the magnetites of New Jersey still remain an important part of the burden of the furnaces in the Lehigh district.

The successful use of anthracite coal as fuel for iron smelting measured the start of the pre-eminent position which this country enjoys in the manufacture of pig iron. It is therefore of more than passing interest to take cognizance of the recent completion of a modern blast furnace at Catasauqua, Pa., on the site of the pioneer plant which first produced pig iron as a commercial success with the above mentioned fuel. By the rebuilding of the number two furnace at its Crane Iron Works division, the Empire Steel & Iron Co. has accomplished a noteworthy addition to the present trend of reconstruction of American iron makers.

In order to more clearly comprehend the significance of the work, it is of interest to look backward over the history of the central unit of the Empire Company. In the period between 1825 and 1840, the iron masters of the eastern section of Pennsylvania made many attempts to smelt iron by using anthracite coal as fuel, but with the exception of a three months' campaign at Pottsville in 1839, the results were unsuccessful from a commercial standpoint.

The Lehigh Coal & Navigation Co. was anxious to have iron works established on their waterway and thereby use their fuel. Its board of directors therefore passed a resolution early in 1839, offering to give in fee simple all the water power of any of their dams between Allentown and Parryville, excepting that necessary for navigation purposes, to any company which would expend $30,000 in building iron works to smelt ores with anthracite coal as fuel.

The Lehigh Crane Iron Company, organized on the sixteenth day of May, 1839, signified its intention of accepting the proposition of the navigation company, and sent its representative, Erskine Hazard, to Wales to engage David Thomas, a practical furnaceman, to come to America to supervise the erection of a plant. Thomas had demonstrated the successful operation of Neilson's hot blast to anthracite iron smelting at Ynyscedwin Iron Works in his native country. Upon his arrival in this country he immediately repaired to the site selected by his employers, a few miles from Allentown, and commenced the erection of the first furnace. Construction work was attended by difficulties unknown to our present engineers, as in those early days there were no railroads in the Lehigh valley, and there were but few foundries or machine shops capable of making castings of any size. A large part of the blowing apparatus was brought over from England, and even some of this had to be remade in this country, owing to the fact that a portion of it was too large to be taken over in the vessel chartered for the purpose.

The original furnace was constructed of stone of the usual type of the period, 30 feet square at the base and 45 feet in height with a 10-foot chimney surmounting the furnace head. The bosh was 12 feet in diameter, while the hearth tapered from 5 feet 6 inches to 4½ feet. The hot blast oven was built on the ground and was arranged for coal firing, as no attempt was made in those days to bring gases down from the open top of the furnace.

The blowing apparatus consisted of two vertical iron cylinders worked by a pair of enormous wooden walking beams, bound with iron straps, which were driven by gears meshing into segments on the periphery of a breast water wheel 12 feet in diameter and 24 feet in length.

After numerous delays, the furnace was lighted on July 3, 1840, and the following day made its first cast of some four tons of iron. The enterprise being a success, the company erected a second furnace in 1843, using similar lines, but improving the arrangement of the hot blast by placing it near the furnace head. A third unit was built in 1846, giving a total weekly capacity of 420 tons to the works.

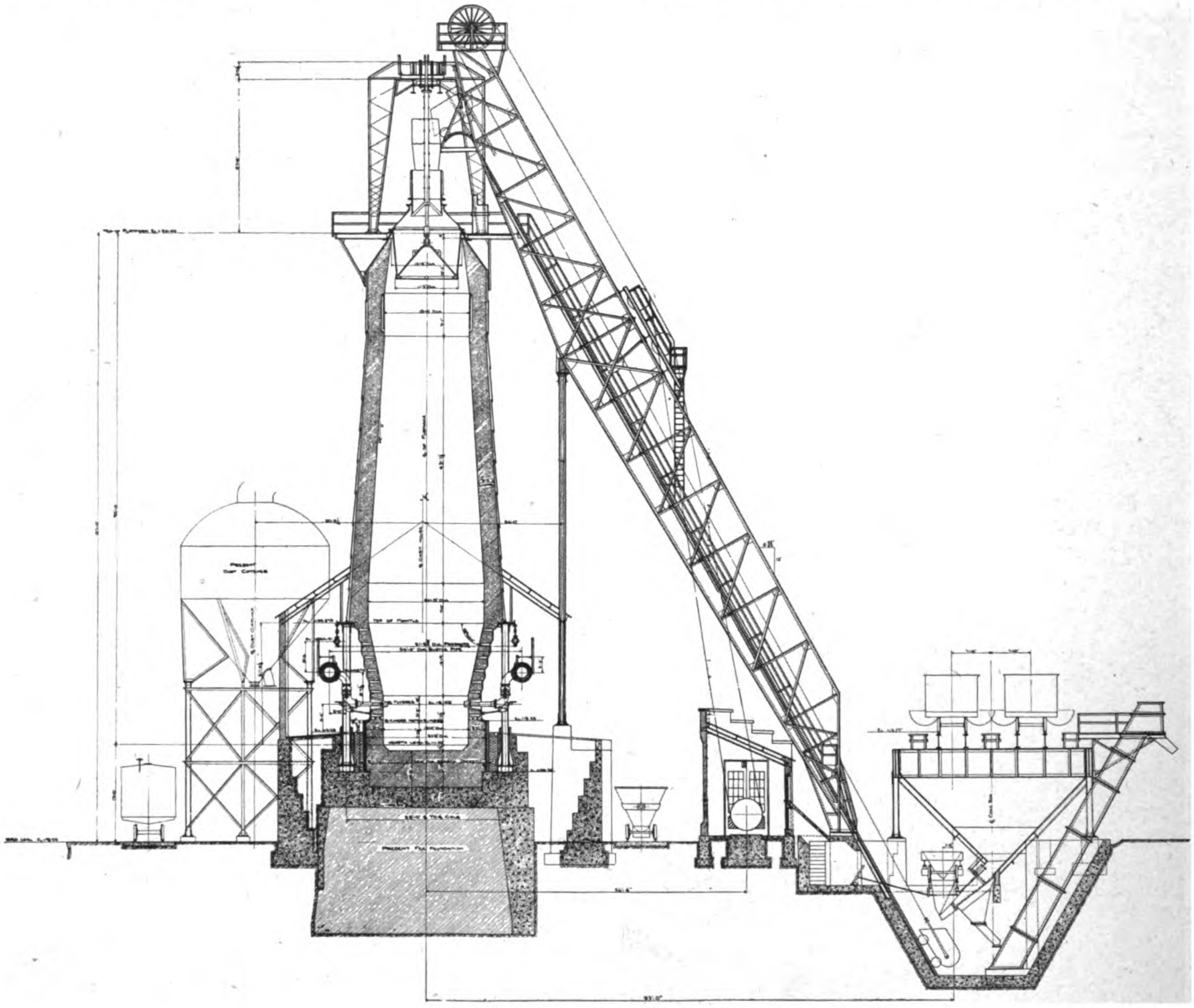

Fig. 2—Cross section of the furnace.

Until the year 1855 ushered in the advent of the opening of the Lehigh Valley railroad, all the raw materials for the plant were brought in by canal boats or by teams, and the countryside must have swarmed with wagons draying in the local brown ores from the neighboring counties.

In 1880, the No. 3 furnace having fallen down, it was determined to dismantle the original three stacks, leaving, however, Nos. 4, 5 and 6, which were built in 1849, 1850 and 1868, respectively. Two new furnaces, designed as Nos. 1 and 2, were built in 1880 and 1885, and at this time Whitwell stoves were installed, these being built under the personal supervision of Thomas Whitwell, and were the first of this type erected in Eastern Pennsylvania. The furnaces were not of the modern type of shells resting on columns, but consisted of stone work supporting the boshes, with iron extensions giving them the appearance of old fashioned railway water tanks.

The Crane Works were described by an early writer as a "noble pile," and old illustrations of the plant are hard to recognize as those of a smelting works, although they presented a picturesque aspect.

In the early 60's the furnaces at Catasauqua probably constituted the largest single plant in the United States, and furthermore, greater production per furnace than was reached elsewhere was accomplished by the bold steps taken by Thomas in blowing the stacks with higher blast pressure than had ever been previously attempted. An early writer, in commenting on Thomas' efforts, remarks: "The consumate skill and long experience of the manager must no doubt avoid or redress the ordinary troubles of the process, but the immense production can be accounted for only by the enormous consumption of oxygen. It is a satisfactory evidence of the constancy and reliability of the chemical and mechanical laws at our command for making iron that the introducer and oldest purchaser of anthracite iron in America has not been superseded, but is able still to lead off the greatly enhanced production with high figures. It is evidently no game of chance, but a trial of practical wisdom based on experience and insured by the improvement of all the means at the disposal of man."

In the past 30 years the work of rebuilding and dismantling contracted the plant to but two furnaces known as Nos. 1 and 2, and during this period much of the original plot was restored to its former condition.

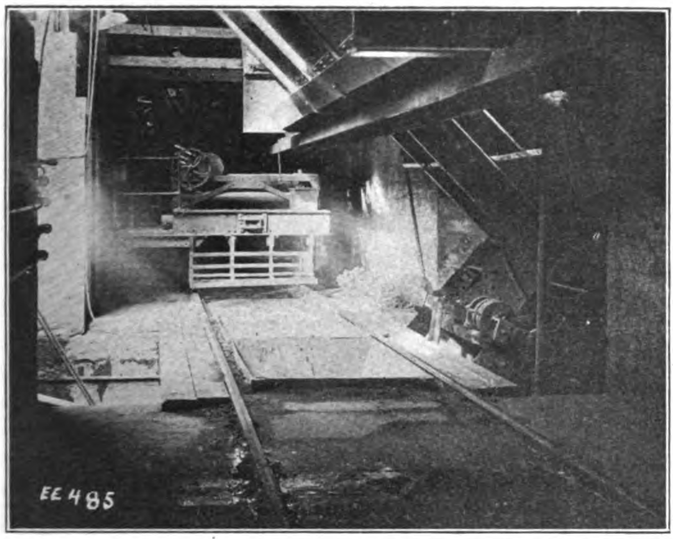

Fig. 3—Shows the scale car underneath the storage bins with the skip pit and coke bin discharge chutes in the foreground.

It may well be understood, therefore, that when the Empire Company decided to build a modern furnace on the site of a much rebuilt plant, that their engineers were confronted with difficulties widely in contrast to that of laying out work on virgin ground. Many of the existing appurtenances were to be retained for economical reasons, and it is to be borne in mind that the expansion of the plant was limited on one side by the Lehigh canal and on the other by the main street of the town of Catasauqua, while the ground between these boundaries is of limited area. This space was ample for even the six old stacks, for in the early days the necessary raw materials were not of great proportion, and the stock trestles were arranged between the furnaces as well as being adjacent to the canal.

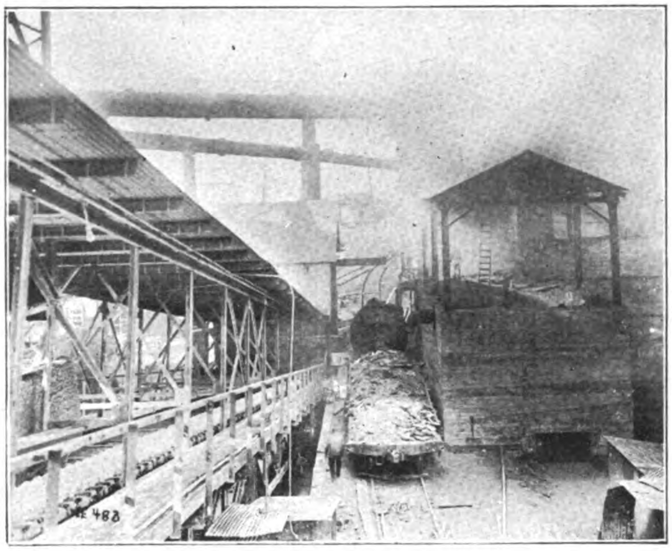

Fig. 4—shows the 75-ton mixer type hot metal ladle receiving iron from the furnace. The pig casting machine is shown at the left.

Great credit is therefore due to the engineers and contractors, Arthur G. McKee & Co., of Cleveland, Ohio, who furnished designs and materials and supervised the erection under a fixed contract. In this work they followed the ideas and suggestions ably advanced by the officers of the Empire Steel & Iron Co., Messrs. Leonard Peckitt, president; James A. Stillman, secretary, and M. O. Knauss, superintendent.

The improvement program involved the entire reconstruction of the furnace stack, the addition of a s[illegible] bridge, [illegible] tor, stoc[illegible] hoist engine, scale ca[illegible] casting machine [illegible] s, one new stove, new boilers, pumps, water tower and other auxiliary equipment.

The old stack was completely demolished and the foundation enlarged for the new work The new furnace has a height of 90 feet, hearth and bosh diameters of 15 feet and 20 feet 5 inches, respectively, and a 78-degree bosh. The shell is ½-inch plate with ¾-inch bottom ring, ⅝-inch top ring and ¾-inch top cone. The hearth jacket is 1¼-inch plate 9 feet high, cast iron hearth cooling plates 4 inches thick with cooling pipes being placed inside the hearth jacket. The tuyere breast is 4 feet 9 inches high of 1-inch plate. Eight rows of copper cooling plates are used in the hearth and tuyere breast. The new lining involves a total of 332,000 brick (9-inch equivalents), giving a furnace volume of 19,310 cubic feet. Cast iron wearing plates 6 feet in height are suspended from the top cone for protecting the brick work at the stock line. The large bell is 11 feet 3 inches in diameter, the small bell 5 feet 6 inches. The McKee revolving stock distributor is electrically driven and controlled, its operation being interlocked with the hoist engine so that the revolving and charging cycle is entirely automatic. The furnace top is equipped with a 25-ton trolley hoist for dismantling the furnace for repairs, and for raising material from the ground to the furnace platform.

The skip bridge is double tracked, of the through truss type, supported by a shear leg, independently of the furnace stack. The bridge has a steel plate deck and a stairway from the ground to the top platform. The skip cars have a capacity of 100 cubic feet of material each. A new steam hoist engine was installed, having 12x14-inch cylinders and a double grooved drum 66 inches in diameter The hoist engine house is placed directly under the skip bridge—as will be seen in the photographs, the ropes being led through the bridge by guide sheaves.

The stock bin structure is of steel and reinforced concrete, comprising a double tracked coke bin and 14 single tracked ore bins. The coke bin is of all steel construction with a capacity of 19,500 cu. ft. Two gravity chutes discharge the coke, over cascade screens, directly into the skip cars. The coke bin gates are controlled by the hoist engine operator and are in view from his post. The 14 ore bins are of steel, suspended from a concrete structure, each bin holding 2,130 cubic feet, giving a total bin capacity of about 1,879 tons of ore. The ore bins discharge into an electrically driven scale car of 80 cu. ft. capacity, the bin gates being continuous so that the entire contents of each bin can be discharged.

A single strand pig casting machine was installed in a structure of sufficient size to house a second strand when required. A 75-ton mixer type hot metal ladle car receives the metal from the furnace runners and delivers to the pig machine. The ladle car in receiving and pouring positions is shown in the photographs.

The boiler equipment of this furnace formerly consisted of approximately 3,480 hp of water tube boilers. This was augmented by the addition of two new 505-hp Stirling boilers which are equipped with Kling-Weidlein aspirating type burners for blast furnace gas. Other additions to the power equipment consist of two steam turbine driven pumps, each with a capacity of 2,500,000 gallons per day. A water tower giving storage for 80,000 gallons was also installed.

The increased size of the rebuilt furnace made necessary additional stove heating surface, and this was accomplished by adding one 20x100-foot McKee side combustion stove to augment the three Cowper stoves of smaller dimensions built in 1909. This work also included new air and gas mains and their connections.

The new stack is designed to produce foundry, forge and basic iron from a mixture of about 65 per cent New Jersey magnetite ore from the mines of the Empire Steel & Iron Co., and 35 per cent non-Bessemer Lake Superior Mesabi ore. Local stone is used, with Connellsville coke as fuel.

The rebuilding program at Catasauqua has brought to a culmination many years of changes and additions, which at best may be described as temporary and leading up to the present completely modern type of furnace. A number of other eastern iron manufacturers have also made notable improvements at their plants, namely the Wharton Steel Company, Wharton, N. J.; the Robesonia Iron Company, Ltd., Robesonia, Pa.; the Thomas Iron Company, Hokendauqua, Pa., and the Eastern Steel Company, Pottstown, Pa. The improvements made at the two plants first mentioned have been the subject of previous articles, and a complete description of the other plants will appear in the near future.

Recent Improvements in the Manufacture of Welded Pipe

While There Have Been Many Improvements in Appliances for Butt-Welding Pipe Since the Introduction of This Process, the Method of Finishing Has Not Been Materially Changed for Some Time.

By **F. N. SPELLER**, Member A. S. M. E.,
Metallurgist National Tube Company.

WHILE there have been many improvements in appliances for buttwelding pipe since the introduction of this process, the method of finishing has not been materially changed for some time. The process described in this paper involves welding the pipe larger in size than was formerly necessary, then after one rounding up pass the temperature of the pipe is reduced to a little above the annealing point (about 1,800° F.), after which the diameter is further reduced by passing through several rolls to the finished size. The straightening and cooling operations are then carried out as heretofore.

The object of these additional operations is primarily to remove the welding scale from the pipe, especially from the inside, so as to lessen the tendency for pitting and facilitate galvanizing or the application of other coatings. Incidentally this additional work done on the steel tends to improve the material and the weld.

Introductory.

The making of steam, gas and water pipe of wrought iron by the buttweld process has been carried on for nearly 100 years with many important changes to facilitate handling of the skelp, rapidity of welding and economy of operation. The process to be described has to do with the removing of welding-scale for the purpose of improving the finish and quality of the product. Before going into details it may be well to outline the more important steps in the development of this industry, chronologically considered.

Historical Development*.

The first attempt to make welded pipe by butting the edges of the hot plate together and forging, instead of first lapping them one over the other, was carried out in England by James Russell in 1824. This was improved in 1825 by Cornelius Whitehouse, whose process of drawing the skelp through a pair of bell-shaped dies forms the basis of the present buttweld process. The Whitehouse patent was assigned to James Russell and was used by him and other manufacturers after the patent expired.

In the United States the first furnace for the manufacture of buttweld pipe was built between 1830 and 1834 by the firm of Morris, Tasker & Morris, Philadelphia, Pa. At the present time there are 55 buttweld furnaces in this country with a capacity of approximately 1,000,000 tons per annum.

The earlier methods were, by contrast with later means, naturally cumbersome and slow. The first important improvement consisted of a fixed slotted die substituted for the original two-part die. Through this slot a pair of toothed jaw tongs was introduced, which grasped the heated skelp. By means of a draw bench chain the tongs and strip of skelp were drawn through the die and the flat skelp folded into tubular form with the edges butted against each other. This idea with modification is still used in forming the skelp for lapweld pipe.

On March 25, 1875, a patent was granted to George Matheson of McKeesport, Pa., for a device consisting of a fixed bell-holder slotted at the top, and a funnel-shaped bell which could be easily inserted and removed from this holder. Prior to this time all pipe was made from a strip of iron which was heated once, drawn through a die and then reheated to a welding heat and then drawn through a pair of funnel-jawed welding tongs. Welded to one end of the strip of skelp was a piece of round iron bar (the tag) with a knob on the end that engaged to a buggy which the operator also engaged to a draw bench chain. The funnel-shaped die of Matheson combined the two operations of bending the skelp and welding, materially decreasing the cost and increasing the rate of production. About 1895 a variety of pipe drawing tools and tongs came into use. The tongs were so designed as to pass through the funnel-shaped welding bell and grasp the pointed and upturned end of the skelp in the welding furnace and then engage to the chain of the draw bench. This greatly increased production and tended toward more uniform work.

Heretofore the plates with tags attached had been charged from the same end of the furnace from which they were drawn when heated, the welder and the men charging the cold skelp had to work in the same space and were therefore crowded and hampered in their movements. The introduction of practical improvements in drawing appliances paved the way for the next notable development by which the skelp was charged from the back end of the furnace through a low horizontal slot extending the full width of the furnace. By this means the furnace was kept full of skelp at all times when regularly operated, a cold piece being charged as a hot one was drawn and all parts of each piece of skelp are in the furnace the same length of time, whereas before the end first charged was the last drawn out. This system was patented by Mr. Peter Patterson of McKeesport, Pa , April 20, 1897. Since then electrically driven mechanical charging machines have been introduced, doing away with considerable laborious work.

The length of pipe welded in one piece had been increased from a few feet to 20 feet. The next step was to build a 40-ft. or double length furnace, the first of which was put into operation at McKeesport, Pa., in 1901, and was completely successful on pipe up to and including 3-inch size, the largest pipe that is usually made buttwelded.

Prior to 1886 wrought iron was the material universally used for welding pipe and other welding operations. The demand for a more uniform and more economical material for pipe manufacture led to experiments in the use of Bessemer steel for this purpose at the old Riverside Iron Works, Riverside, W. Va. Open hearth is now sometimes used, but it is somewhat more difficult to control in respect to welding quality, therefore it is perhaps fortunate that these early experiments happened to be made in a plant where only Bessemer steel was available, as Bessemer steel has since proven to be better adapted for standard pipe than open hearth or other grades of steel. From this time on the use of steel pipe has steadily increased until it now forms over 90 per cent of the entire production of wrought pipe in this country. Much has been done towards more uniform quality of product and increased production of steel pipe through the building of complete pipe producing plants, wherein the pipe is made complete from ore to finished product The influence of uniformity on durability was recognized and improvements in the method of rolling were introduced to produce a more uniform working of the metal in rolling the skelp from the bloom. Most of the work in rolling the ingot into skelp is naturally done lengthwise. By means of a special design of knobbed roll the bloom was subject to lateral work while being elongated and reduced in section which rendered the metal more uniform in density and therefore in better condition to resist corrosion.

The experiments which led up to this treatment were made on an old three-high skelp mill at McKeesport on which the middle tongue roll was deeply grooved. The faces of the projections had an angle to each other of about 100°. The blooms should be heated to a comparatively high and uniform temperature and all loose scale removed by a jet of steam or water during the rolling. This process was later applied to continuous skelp mills and was determined "roll-knobbling" by the author, but by mill parlance became better known as "Spellerizing." Later, as a result of our study of the various factors which came into the complicated problem of corrosion, the influence of mill scale on pitting of steel became recognized and means were sought to remove the heavy scale which forms in welding pipe. A process was soon developed through experiments made in the mills of the National Tube Company for the removal of this scale from the hot pipe.*

More Recent Developments.

The standard method of finishing pipe consisted in giving the pipe one pass through a circular sizing roll and one pass through straightening rolls of helical section and then cooling on a traveling table.

The finished pipe was covered with a rather heavy mill scale which forms in the heating furnace at the welding temperature. This scale consists essentially of iron oxides, principally Fe_3O_4, with 7 or 8 per cent of silica and smaller amounts of C_2O and Al_2O_3 from the furnace bottom. At the welding temperature this scale is fluid and forms a natural flux for welding, as well as a protection to the metal against excessive oxidation from the furnace gases, so that this is a very essential factor in the welding of pipe, so much so that pipe steel is made primarily so that it will be self-fluxing by readily forming this fluid oxide at as low a temperature as possible. Wrought iron carries considerable excess of fusible slag and oxides intermixed with the metal, whereas pipe steel, when properly made, readily forms a suitable fluxing scale when heated to the welding temperature. The melting of the welding scale affords the welder a sharp indication of the temperature of the skelp, which is much better than any pyrometer for this purpose. On cooling, the welding scale passes through a viscous stage and then quickly becomes brittle at a temperature at which the steel is still quite easy to forge. Most of the scale on the outside is removed in the sizing and straightening rolls, but inside the pipe this scale is often 1/32 or 1/16 inch thick in patches, and when cold is firmly attached to the metal like an enamel. Several means have been used to remove this scale to prepare the pipe for galvanizing and other coating operations. Pickling in acid is the most common method employed, but is the least effective on the inside of pipe where the scale is most firmly attached and, further, as the scale is very irregular and rather thick in spots portions of the metal are likely to be damaged by over pickling before all the metal is cleaned. Mechanical cleaning by sand blasting and cold rolling has been tried, but has not been thorough enough, besides being quite costly.

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*Much of this information on historical development has been obtained from a thesis on Buttweld Pipe, by C. D. Terry, assistant to general superintendent National Tube Company.

*U. S. patents granted to F. N. Speller covering scale removing equipment:

1,149,696—Welded pipes. August 10, 1915.

1,149,697—Methods of making Buttweld Pipes. August 10, 1915.

1,171,757—Method of finishing welded pipe. February 15, 1916.

By making the diameter of the pipe larger and then reducing the size and elongating the pipe at the highest temperature at which the scale is brittle enough to remove, it has been found possible to clean the pipe in the process of hot finishing and at the same time produce a better material in other respects. This new process of finishing is very advantageous. It will be seen that two additional steps are introduced in the finishing operation in order to produce what is practically a scale free pipe, (1) a partial cooling from about 2,500° to 1,800° F., (2) a reduction in diameter and elongation of about 10 per cent in length by means of a series of horizontal and vertical rolls, by which the brittle scale is cracked and separated from the steel. The pipe is then straightened and cooled as usual, during which a thin film of new oxide forms sufficient to protect the metal from rusting while being handled. A thin coating of suitable lacquer is now applied, which affords substantial protection to the pipe in storage. The main object of these scale removing and cleaning operations is to make possible more uniform galvanizing. This also has an important bearing on the manufacture of all kinds of coated pipe and conduit for electrical purposes.

The scale free surface rusts much more uniformly than when covered with the heavy mill scale, as there is quite an appreciable current generated between mill scale and iron which results in pitting of the metal. For this reason it is usually of advantage to have the scale removed, especially where the pipe is buried in the ground or subject to other active corrosive influences. The fact that mill scale is usually the controlling factor with respect to pitting of iron and steel has been demonstrated by several other investigators besides ourselves. Some tests made in hot water service at Harvard University recently covering a period of three years indicate that this scale free pipe was pitted to little more than half the depth of pitting found on the regular wrought iron and steel pipe used for comparisons in this test.* It may be said as a rule that the more perfectly the surface is cleaned the more uniform will be the corrosion. This is the reason that such care is desirable in the removal of scale and dirt before painting iron or steel. The scale removing process described was first developed in 1913 and has recently been put into general use in the buttwelding mills of the National Tube Company.

In hot galvanizing a saving of considerable time and about 50 per cent of the acid has resulted from the use of scale free pipe as well as a much improved product, particularly with respect to the inside coating.

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*Prof. M. C. Whipple, *Journal N. E. W. W. Association*, March, 1920, page 42.

NEW DRIVER-HARRIS ROLLING MILLS

E. Cooper Willis, who has been engaged as general superintendent of the hot mills and engineer of the Driver-Harris Company, Harrison, N. J., has been in Pittsburgh recently completing the purchase of equipment for the new rolling mill plant on which the company is about ready to start construction. The mill building, which is of all steel construction, 275 ft. long, 100 ft. wide and 22 ft. in the clear, is to be fabricated, erected and completed by the American Bridge Company. The building will be equipped with a 20-in. break down and plate and sheet train, one 9-stand 9-in. mill for wire rods and merchant mill products, four modern type heating furnaces and two electric annealing furnaces. The 20-in. mill is to be driven by an 800-hp d.c. motor and the 9-in. mill by a 500-hp d.c. motor. A motor generator set for converting alterating to direct current also is part of the equipment. The mills will run on 600 volts and have a speed ratio of 600 to 300, this flexibility being required on account of the character of the products the company produces.

In addition there will be an open hearth plant constructed. At present the Driver-Harris Company ore operating two Herault electric furnaces. The open hearth will be used for carbon steel, electric furnaces being used for alloy metals.

The products include nichrome, Monel metal, brass and various carbon steels. M. Hoagland Sons & Co., Rockaway, N. J., has the contract for building the mills. The Westinghouse Electric & Manufacturing Company and the General Electric Company will furnish the motors and generator sets, and Fawcus Machine Company, Pittsburgh, the drive for the 20-in. mill. Mr. Wills formerly was general superintendent and engineer at the Rahway, N. J., plant of Nagle Steel Company, and the layout and design of the new plant of the Driver-Harris Company is entirely in his hands. When completed he will become general superintendent of this plant. F. L. Driver is president of Driver-Harris Company and Leon O. Hart general manager.

LIGHT ARGENTINE STACK.

What is believed to be the first blast furnace to be put in operation in Argentina has been lighted near Jujuy. Consul Wilbert L. Bonney has reported to the bureau of foreign and domestic commerce. Near Jujuy are deposits of both iron and lead ores. The furnace project employs 90 men and is producing about 24 tons of pig iron a day.

The Logic of Roll Design

Describing in Detail the Design of Rolls for Guide Mills and Part of the Formula in Use Today on This Work.

By **W. H. MELANEY.**

PART VI.

THE design of rolls for producing ordinary merchant bars such as rounds, squares and flats, presents no difficulty and is subject to simple rules easily applied when understood.

Most of these are rolled from a square billet of a size to suit the diameter of the rolls on which they are to be rolled and then reduced in the roughing rolls to a billet of the proper size to make the particular bar desired.

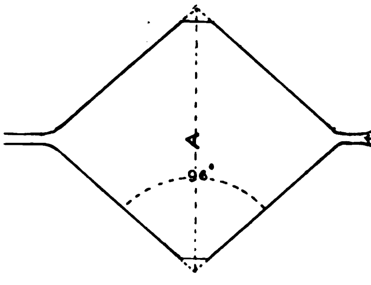

FIG. 1-B

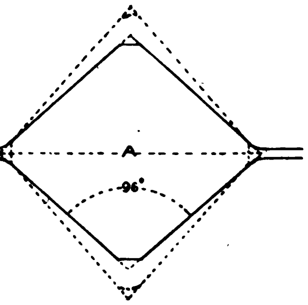

FIG. 1-C

As stated in a previous article, the roughing rolls are usually of the open square type of grooves with perhaps one or two box passes where the billet is of large size for that particular mill. An open square groove under this condition would reduce the diameter at bottom of the groove to below the size of the neck, due to its being placed in the roll diagonally.

An open square groove is the ideal method of reducing billets of six inches square and under, as it permits the production of any size of billet that may be required within close limits and also permits the squaring up of the billet by returning it through the same sized groove after giving it a quarter turn. It does not, however, permit the maximum amount of reduction to be used.

Where rapid reduction is desired in order to reduce a larger billet to small size as in the production of small rods or bars, use is made of a flat oval groove in connection with the open square groove, the billets being entered flat into a comparatively shallow oval groove and then edged up into a much smaller square groove again. This process is continued until the desired size of billet is provided from which to make the finished bar.

This type of rapid reduction oval should not be confused with an oval for producing a finished guide round, as the reducing oval is much shallower and wider.

Designing Open Squares.

The usual method of laying out open square grooves

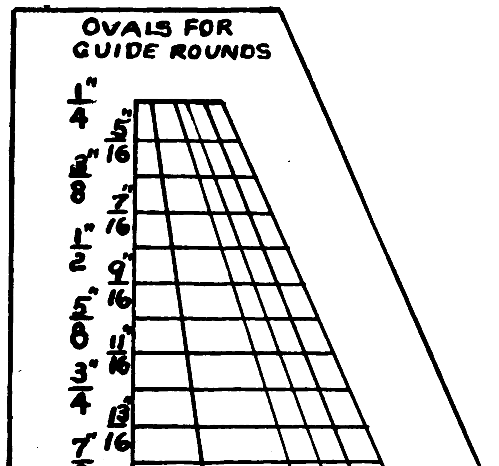

FIG. 2

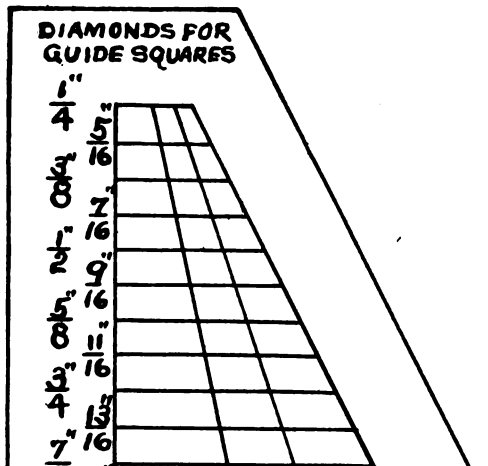

FIG. 3

is to mark off on the center line a space equal to the diagonal of an open square, six degrees open and of a size sufficient to permit the billet you have decided to use to pass through without overfill (Fig. 1-B.) Then set the compasses the width of the vertical diagonal of the open square (Fig. 1-B) and use this for the horizontal diagonal of the next groove (Fig. 1-C) as shown at A, this gives the maximum reduction that can be produced on a groove of that size and opening. The overfill is prevented by the fillet at bottom of groove as shown in illustration; this process is continues from groove to groove until the minimum size of billet required is obtained.

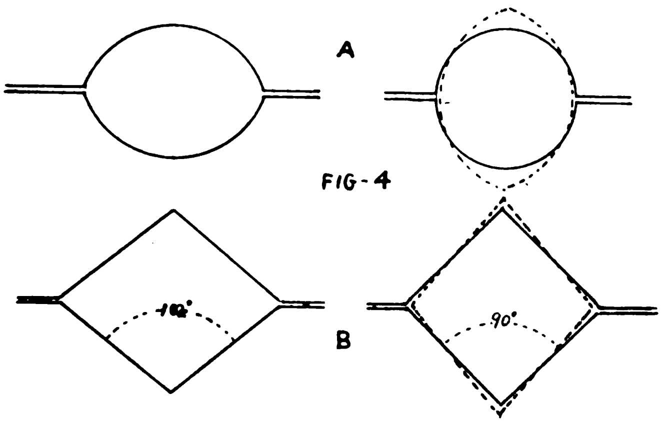

FIG-4

Of course, where a particular size of billet is required from any groove, the width of the groove on the center line may be made to suit the requirement, provided it is not less than the vertical diagonal of the preceding groove, but may be as much wider as necessary. The wider the groove the less the reduction will be.

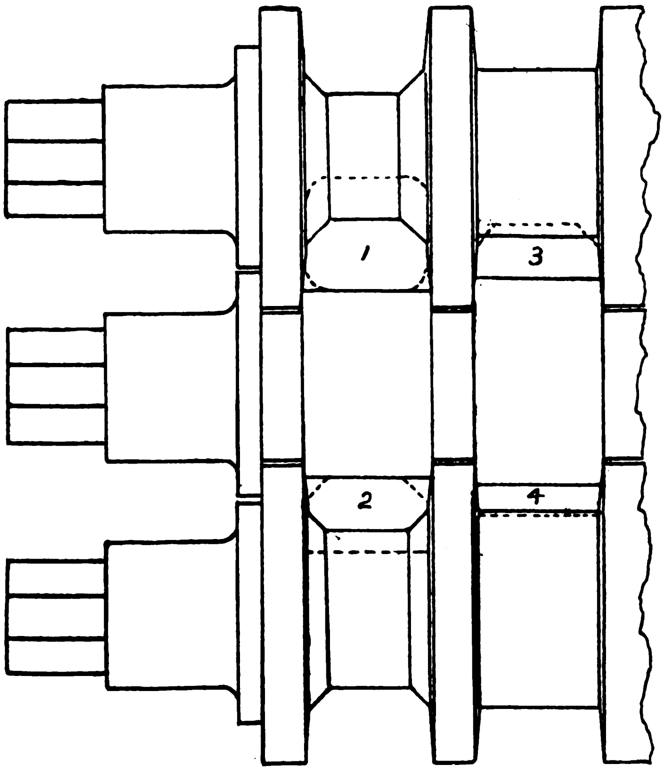

FIG.5

Rolling Round or Square Rods.

Now if a small round section is desired for the finished product a size of billet is selected from the roughing rolls and further reduced in the strand rolls by means of reducing ovals and open squares until a square billet approximately the size of the finished round is obtained. This is then entered flat into an oval groove for the purpose of shaping in and flattening it so it will enter the round finishing groove, the oval groove at the same time finishes the two sides of the bar that will be opposite the open spaces between the top and bottom finishing rolls. The oval is then edged up into the round finishing groove and has just sufficient cross section to slightly overfill the round groove, but overfill is prevented by slightly underfilling the oval as sharp edges on the two edges of the oval, which would result if the oval was completely filled up, are not desired. The thickness of the oval must be less than the diameter of the finished round to allow for sufficient spread, without marking the sides of the round where the break between the rolls occurs. In other words, just permitting the round groove to evenly fill up. (See Fig. 4-A.)

If a finished square section is desired instead of the round rod the same operation is followed, up to the production of the proper sized billet to make the square. This is then given a pass through a diamond groove, usually having an angle of 102° or 12 degrees open, thus flattening the billet sufficiently to enter the finishing square groove and at the same time finishing the two corners of the square that will come opposite the space between top and bottom rolls in the finishing set. This diamond is given a quarter turn and edged into the finishing square groove, sufficient spread having been allowed to prevent any overfill. The square groove simply finishes the other two corners of the bar and shapes it up to a 90-degree angle of the square desired. (See Fig. 4-B.)

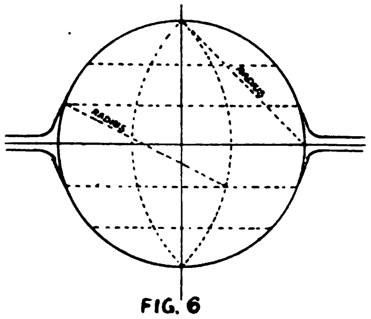
FIG. 6

Where Charts Can Be Used.

The sizes of ovals and diamonds for the various sizes of rounds and squares are proportional and can therefore be definitely laid out from a chart such as shown at Fig. 2 and Fig. 3.

While there may be a difference of opinion among roll designers as to the exact shape the oval or diamond should be, some preferring a shallower and wider groove while others prefer the deeper and narrower ones, this is simply a matter of opinion. The essential features are that it contain enough cross section to just fill the finishing groove when the oval or diamond is properly filled up by the billet and have enough spread to take care of overfill.

The less the spread that can be used without overfill the less the scale will be broken on the two sides of the round or square which are finished in the oval or diamond grooves and the nicer looking the finished rod will be. The charts shown are based on present day practice.

Rolling Rectangular Bars.

Where simple rectangular bars, commonly called flats, are to be rolled, the usual process of reducing the billet to the proper size is followed the same as for rounds or squares.

It is obvious that a slightly smaller square billet than the width of the flat is required for exactly the same reason as stated in the preceding process, namely to provide for spread.

This billet is then reduced in thickness only, usually getting three or four passes in tongue and groove rolls with positive width of grooves and with a slight taper in the sides of the grooves and just sufficient spread to prevent overfill and insure free delivery of the bar; this taper in thick flats amounts to from one to one and a half degrees in each side of groove and on thin flats to two and one-half degrees, while on grooves for rolling hoop it would be twice this much. This is to allow easy delivery on thin flats which otherwise might stick and buckle up in the groove. It also permits the grooves to be brought back to width when rolls are re-turned.

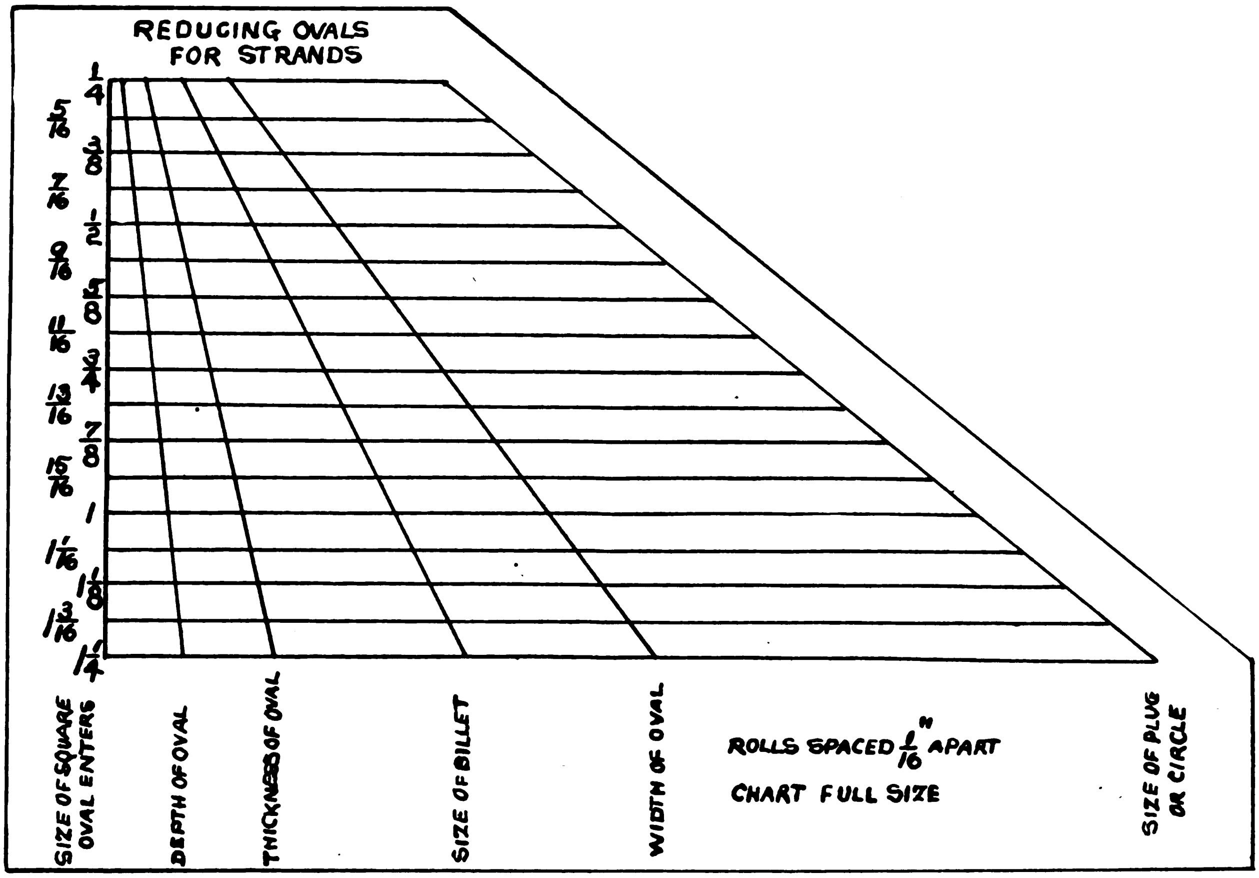

FIG. 7

On flats the main essentials are that all four corners of the bar be filled up sharp, that the edges of the bar be a right angle to the top and bottom of the bar and that provision be made to prevent overfill.

The overfill is prevented in this case by using sufficient fillet in the bottom of the first groove to prevent the heated metal squashing up between the tongue and side of the groove on the next pass. Any tendency to overfill on the first groove being amply taken care of by the rounded corners of the billet as it comes from the roughing rolls. (Fig. 5.)

The pass before the finishing pass should have sharp corners the same as the finishing pass, otherwise it would be difficult to get the corners sharp on the finished bar as the reduction on the finishing pass is light.

It is apparent that the side of the bar that has its corners filleted off in one pass must be so entered in the succeeding pass that these filleted corners will be next to the tongue and thus by leaving an open space prevent any possibility of the metal squashing up between the collar and tongue of the groove.

On flat rolls of the tongue and groove type, the bulk of the reduction is on the first pass, as a square billet is usually used for ordinary sizes, but an extra pass is sometimes used to flatten the billet for large sizes.

Other methods of rolling flats, especially from high carbon steels, will be described in a future article.

Hand Rounds and Squares.

Another method of producing rounds and squares which are too large to roll by guide on the mill it has been decided to roll them on, is known as hand rolling.

By this method only short bars can be rolled successfully, usually not longer than 20 feet, as the operator must retain his hold upon the bar until the last end of the bar almost reaches the rolls, especially in the case of hand rounds. This is to prevent any tendency of the bar to turn or twist during the time it remains in the rolls.

In hand rolling, instead of getting one pass in the finishing groove, as in the case of guide rolling, it usually gets four passes, the bar being given a quarter twist after each pass before being re-entered in the groove. Such bars are rolled on two-high rolls, the bar being pulled back over the top roll after each pass.

A square billet is used to start with, but is partly shaped up in a leader pass which is usually one of the larger grooves in the same rolls.

The rolls have as many different sizes of grooves for standard sizes of rounds or squares as the length of the rolls will permit, the two end collars being left several inches wide to prevent interference of the tongs with the sides of the housings.

Slowing Down Speed for Hand Rolling.

In hand rolling as the operator retains his hold upon the bar it is necessary to slow down the mill while doing this work and for this reason more than one speed is required. The electric motor with a variable speed is nicely fitted for this work.

Designing Grooves for Hand Rounds.

In designing grooves for hand rounds, the grooves are cut away or opened out where the parting between the rolls occurs and the corners of the grooves are also rounded to prevent any danger of marking the bar while rolling.

By giving the bar four passes in the finishing groove with a quarter turn of the bar at each pass, the bar is almost perfectly rounded. Fig. 6 shows one method of determining the opening in a hand round groove that is considered good practice.

A hand square is rolled similar to a hand round except that the groove is square with the corners nicely rounded. The groove is also made about one degree open square.

Errata.

An error occurred in the table accompanying the article on "The Logic of Roll Design" which appeared in the September issue of THE BLAST FURNACE AND STEEL PLANT magazine. Under the table for guide or bar mill rolls, the letter at the head of each column was transposed and was not in accordance with the roll sketch shown in another part of the article. They should have been in the following order, A G H C B F D E R, instead of the order in which they were printed.

Gas Producers for Bituminous Coal

Expression of Opinions and Conclusions, After a Number of Years of Study and Operation of Gas Producers—The Points to Be Studied to Secure Good Results Are Outlined.

By HENRY WILLIAM SELDON,
See-Seldon and Associates, Engineers.

THE theory of gas producers and producer gas making has been repeated many times and for such a discussion we would refer anyone to Carl Dichmann's book, "The Basic Open Hearth Process," or some other good authority.

In the following article we will confine ourselves to the expression of opinions and conclusions arrived at as the result of a number of years of study and operation of gas producers.

The term bituminous coal is very broad and we would advise a complete survey of the available coal before installing any make or type of producer. Locate the best coal available for producers and then bear in mind the sad truth that sooner or later you may be compelled to use a poorer grade, temporarily at least. In other words, do not install just sufficient producer capacity and expect to have ideal conditions at all times.

Bituminous coal for gas producers is usually offered for sale by its analysis. A coal having the volatile matter over 30 per cent and an ash content under 10 per cent is sold as a good gas coal. We have found in addition to these analyses it is important to know the amount of sulphur and moisture present as well as the melting point of the ash. Likewise the physical condition of the coal is very important when the amount of coal that can be gasified is being considered. By this is meant the size of lumps, percentage of fines and hardness of the coal. In selecting gas coal aim to get the best coal available in your locality and insist upon the following:

Volatile matter 30 per cent or better.
Ash as much under 10 per cent as possible.
Sulphur under 1 per cent if possible.
Moisture low as possible
Melting point of ash high as possible.

For the ideal physical condition we prefer the coal which passes through a 2″ mesh and remains on a ⅜″ mesh. Gas coal containing not over 25 per cent of fines is not objectionable. We have a preference for hard coals.

When a certain rate of coal gasification is mentioned it is important to know the kind of coal and its physical condition. The best test of any gas coal is a trial in the producer.

We do not want to create the impression that low grade gas coals cannot be used in gas making, for they can, but we do want to emphasize the fact that some coals make more and better gas than others and that good coal is necessary if the commercial rating of a gas producer is to be obtained.

Sample analyses of the gas coal used in this district are as follows:

	No. 1	No. 2	No. 3	No. 4
Volatile matter	35.52	33.00	33.60	31.53
Fixed carbon	53.31	57.82	58.28	58.55
Ash	11.17	9.18	8.12	9.92
Sulphur	2.82	.85	.92	.96
Phosphorous	.010	....	....	.024

Sample analyses of ash from producers using the above coals are as follows:

	No. 1		No.2
	Hand Poked—	Mechanical	Hand Poked
Volatile matter	1.12	1.49	.78
Fixed carbon	4.13	12.71	5.24
Ash	94.75	85.80	93.98
Sulphur	.13	not det'd	.08

	No. 3 Hand Poked	No. 4 Mechanical
Volatile matter	.56	1.00
Fixed carbon	4.28	22.41
Ash	95.16	76.59
Sulphur	.05	not det'd

The objections to a low grade or inferior gas coal are as follows:

Cuts down the rate of gasification which in many cases means a shortage of gas on the furnace; necessitates a higher steam pressure with the accompanying wet gas and producer troubles; cuts down the quality of the gas produced and reduces the producer efficiency.

There are a great many makes of gas producers on the market. They differ in their detail construction or method of operating, but the basic principle and design is the same. In general the construction consists of a vertical cylindrical steel shell lined with fire brick with means provided at the top for the admission of coal, means provided at the bottom for the removal of the ash, a hood or distributor inside which introduces the blast (steam and air mixture) and an outlet pipe likewise fire brick lined for conducting the gas away.

This is virtually the description of the hand operated type of producer and we find many in use. With this type of producer the results obtained depend entirely upon the operator. It is possible to make a gas just as rich and for all purposes just as good as can be made in any mechanical producer, but the difficulty exists in obtaining a good gasmaker who can or will operate them. In addition to the labor proposition there are numerous other weaknesses which have all been instrumental in assisting the development of improved designs. Perhaps the weakness which has led most of all to mechanical producers was the desirability and difficulty of maintaining a thick fuel bed on the stationary hand poked producer. This condition led to the development of mechanical agitation and rotating of the producer body.

With the advent of the rotating producer came the mechanical removal of the ash.

The value of a uniform and continuous coal feed was recognized and its development started.

With the mechanical producers advent came increased coal gasification per unit and larger units.

The distribution of the blast inside the producer has received attention and much benefit has been the result.

In the early development of the mechanical gas producer certain mechanical features and principles were discovered and patented; a condition which still exists and which accounts for the numerous different makes of producers on the market. But the fundamental principles of producer gas making are still the same and each manufacturer is trying to approach the automatic production of producer gas by mechanical means.

This we have in operation:

1. Stationary producers which are entirely hand operated, i. e., the coal is fed by hand, the producer is poked by hand, and the ashes are removed by hand.
2. Stationary producers which are partly operated by hand, i. e., the poking is done by hand and the ashes are removed by hand, but the coal is fed automatically.
3. Stationary producers in which the coal is fed by hand and the poking is done by hand, but the ashes are removed mechanically.
4. Stationary producers in which means are provided for mechanically agitating the fuel bed, coal is fed by hand on some and mechanically on others; ashes are removed by hand.
5. Mechanical producers in which the main body of the producer rotates; means are provided for mechanically agitating the fuel bed; the feeding of the coal and the removal of the ash are either done by hand or done mechanically.
6. Full mechanical producers in which all the operations are done mechanically; the fuel bed is automatically agitated; the coal is fed and distributed mechanically; the ashes are removed mechanically; the body of the producer is mechanically rotated.

Under each one of the above types of producer there are many different makes of producers and each one claiming some advantage or superiority over the others. The points of argument usually resorted to are as follows:

1. The amount of coal the producer will gasify per hour.
2. The quality of gas which the producer will make.
3. The amount of steam required per pound of coal gasified.
4. The repair costs and the speed at which repairs can be made.
5. The cost of installation.
6. The efficiencies of the various portions of equipment, such as the method of agitating the fuel bed; the particular type of blast distributor; the method and value of the ash removing scheme; steam or turbo blower or both; amount of labor required to operate, etc.

There are scores of different makes of gas producers in operation and you will find some operators in favor of each one.

The question naturally arises, "Which is the best?" to which we are compelled to answer by asking the question, "What are the requirements, conditions and finances?" Without this information we cannot say.

We offer the following general advice:

Be sure to get ample producer capacity.
Be sure your installation is properly made.
Get or train a competent producer operator.
Buy good gas coal.
Provide ample dry steam.
Coöperate with your gas maker and learn something about gas making as you do about your other operations; it will be helpful to you.

It is surprising the lack of practical knowledge among managers and superintendents regarding the art of gas making. This may be caused by the dirty and undesirable condition in the gas house and the class of foreign labor employed there, but it certainly is not excusable. If this were not the case many gas house troubles would never materialize and some of the furnacemen's excuses would disappear.

There has been a great deal of theoretical written and oral discussion on producer gas and the efficient operation of gas producers, but we have found the practical knowledge absolutely essential.

Our idea of the most efficient operation for any gas producer is that operation which *produces the best results on the furnace.*

FOCH IS EXPECTED

Although cable advices from Paris have stated that Marshal Foch had accepted the invitation of the American Iron and Steel Institute to be its guest at the fall meeting in New York, no official word from the former has reached the offices of that organization. Originally it had been planned on October 28. Before making any final decision, however, the institute will consult Marshal Foch as to what date will prove most convenient for him to make the visit.

New 600-Ton Blast Furnace Plant

The Trumbull-Cliffs Furnace Company New Plant at Warren, Ohio, Now Completed—Many Interesting Features Constructed in This Plant—Record Time Made on Construction Work.

THE new 600-ton blast furnace plant of The Trumbull-Cliffs Furnace Company was completed on June 14, 1921. Work on the plant was started August 15, 1920. On that date the site was an open field on the Mahoning river across from the Trumbull Steel Company and without railroad connections. In one day less than ten months the material and equipment was erected and placed in position, the tracks in, the yard graded and fenced in, machinery turned over and plant ready to make pig iron—in short, everything completely finished. This is record time for construction of a complete blast furnace plant.

The plant arrangement is laid out for future installation of additional blast furnaces as well as for a by-product coke plant. Throughout the design, provision is made for extension without interruption at the pumping, power and boiler houses, furnace and cast house, stock house and stock yard, casting, switching and other operations. Moreover, an extension of water lines, sewers, transmission lines, tracks, stock house and stock yard developes with minimum expense and effort from existing units. As a typical example of provision for expansion, the boilers are so designed with high settings and distinct combustion chambers for gas and coal firing, that stokers may be installed in the existing settings and the electric power output of the plant increased up to 12,000 kw.

Throughout the plant the professional man as well as the casual visitor is impressed with the exceedingly careful study devoted to details, the coördination of groups of allied occupations, provisions for safety, cleanliness and easement of conditions of labor and the provisions for elimination of hand labor in the handling of raw materials, products and waste.

The plant is especially notable for having embodied in its design all the proven and sound elements developed in years of American blast furnace plant construction and operation, and in addition many improvements which experience of the last few years has taught. These new features are not experimental. On the contrary, they go to make up a fully reliable plant built on accepted and conservative lines. Every guaranty is embodied that goes to insure good tonnage, economical practice and continuous operation. The plant is remarkable for the absence of the crudities such as usually accompany design and building for rough manufacturing such as blast furnace operation is usually assumed to be. Considerable attention has been given to appearance and there has been a successful application of architectural design to offices, power buildings, trestles and bridges so that they present a dignified and pleasing appearance.

The layout of the plant is apparent from Fig. No. 1. Present rail connections are the Pennsylvania and Erie railroads across the Mahoning river, but an additional connection is to be provided in the future at the opposite end of the plant by the Baltimore & Ohio railroad. As will be seen, the plant is laid out primarily for delivery of hot metal to the mixer at the open hearth building of the Trumbull Steel Company, and for the time being all raw materials are routed into the plant over the three-track reinforced concrete bridge which also serves as the delivery track for hot metal to the Trumbull Steel Company.

Approaching the plant over the bridge affords a most comprehensive view of the entire layout. As one goes through the plant, he is impressed with the substantial construction, with the completeness of the equipment and the new appliances and practices introduced to better

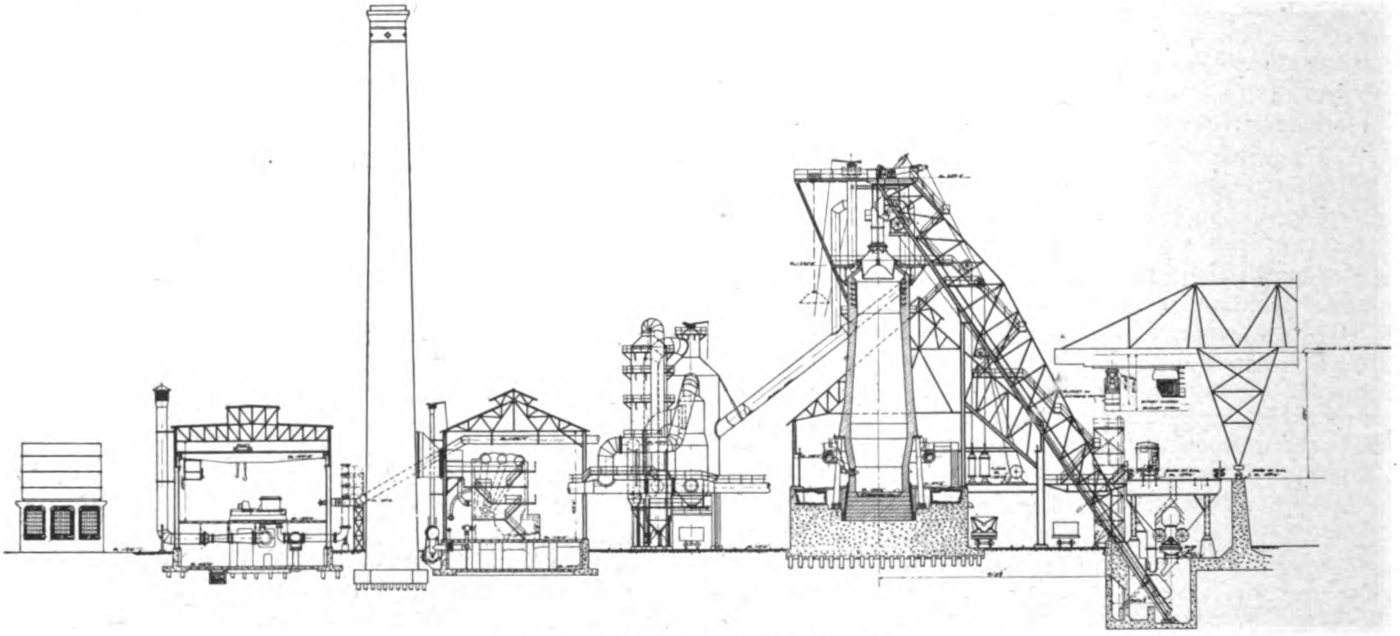

Fig. 1—Section through the new plant.

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the practice and economy of operation. A new feature is to be found in the provision for screening of the coke at the furnace bins. This consists of two rotary grizzly screens, each screen having eight motor driven shafts. These shafts carry discs, and the shafts and discs are so spaced that the rotary grizzly removes material under ¾" in size. The flow of coke from the bin to the grizzly is controlled by a cut-off gate and also by a rotary vane feeder. This provides a steady and even flow of coke over the grizzly. Emergency operation is provided for in a gate and a dead plate furnished over each grizzly so that coke may be by-passed direct from the bin to the skip hoist bucket in case the grizzly is out of operation. Underneath each grizzly is a hopper, one hopper delivering braize direct to a braize elevator, the other delivering braize to an 18" belt conveyor discharging to the braize elevator boot. The elevator is a belt and bucket type delivering to a 24-hour capacity bin. The motors driving the rotary grizzlies, the feeders and the belt conveyor and elevator are electrically interlocked so that the motor driving the vane feeder and belt conveyor cannot be started until the motor driving the rotary grizzlies and the belt and bucket elevator is running. There is also provided a 20% speed variation on the motors operating the rotary grizzlies.

The arrangement of cast house is the next outstanding feature. The cast house is very modernly constructed and has a 94'6" span, 4-motor Cleveland Crane & Engineering Co. crane of 25-ton main hoist capacity, with a 5-ton auxiliary hoist. It spans not only the cast house proper from the foot up to the furnace front, but also spans two tracks, one of which constitutes the hot metal track and the other a track for spotting of cars, for removal of scrap and rubbish, and for unloading into cast house of coke braize, clay and sand. This same crane is also utilized at the slag granulating pit at the foot of the cast house and for this purpose is equipped with a Hayward 1½ cu. yd. bucket, having perforated bowl and manganese steel lips. The crane serves to unload from car or truck and places upon the skip hoist house platform, the motor armatures for the skip hoist or other material required. In the cast house is a brick and concrete structure providing storage for sand, clay and coke braize, in which there is also provided a mixing room for the preparation of these materials.

Convenient access is provided not only by means of stairway, but also by means of an easy incline up the stove foundation to the cast house floor. The grouping of a number of allied operations which must of necessity come under the eye of the blower at the furnace is very noteworthy at this point. The stove platform is at practically the same elevation as the cast house, the cast house being reached by an easy incline not over 2 ft. in height from the stove platform. The stock bins are easily reached by a walkway from the cast house. This walkway passes the skip hoist house where the skip hoist, bell operating cylinders, and distributing mechanism are placed, and also passes the skip incline proper. The blower foreman is thereby able to watch not only the work in the cast house and about the furnace, but, without getting more than a few steps from the cast house, he can always check up on stove practice, or by watching the skip buckets, on the regularity of filling.

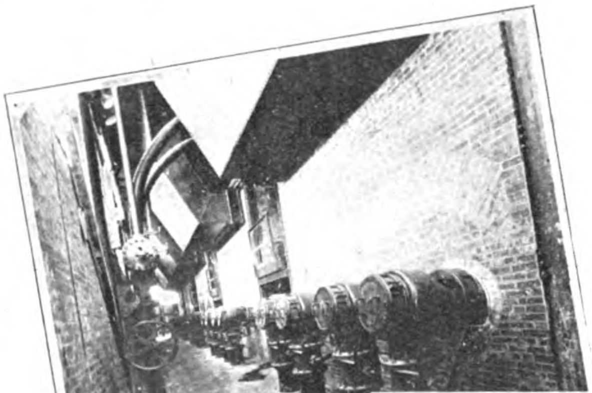
Provision is made so that the furnace can be rodded from the cast house as a check upon the men in the stock house. The shutters in the iron runners are opened and closed by steam cylinders, these being operated from the central control station at the furnace front where the snort valve wheel, the control for the Berg mud gun and signal apparatus are located as one unit. The cast house is supplied with a complete set of blast furnace tools designed by the engineers.

A new type of boiler setting has been installed by the engineers as shown in Fig. No. 6. This provides a high setting of the boiler and gives an exceptionally large volumetric space per bo. hp for complete combustion either of blast furnace gas or solid fuel. The gas burners, consisting of four 14" Birkholz-Terbeck burners, are installed at the back of the boiler. The combustion chamber for gas is under the mud drum, there being provided a distinct combustion chamber of large volume for the burning of the blast furnace gas without dilution by excess air through grate bars, or restriction of combustion by insufficient space, as in the usual setting. At the front of the boiler, grates are provided for auxiliary hand firing. The boiler is so designed that if increased power generation is desired stokers may be installed in the place of ordinary grates, without any work being done on the boiler other than simply building on a Dutch oven extension. The design has proven to have several very important advantages; it enables the boiler to be run at very high efficiency due to complete combustion obtained in the large volumetric space, it enables considerable overload to be carried on boiler due to the generation of high temperatures, and it minimizes the difficulties due to encrustation of the tubes with dust or ash.

In the power house considerable advance in design is shown. Special attention has been paid to daylight lighting. Ample floor space is provided and the engineers have incorporated all the successful features of modern power plant design. These are described in detail in another part of the article, but special mention should perhaps be given to the high intakes provided for the turbo blower, the advanced type of turbo blower installed, the completeness of the electrical equipment, and the well worked out system of water circulation and re-use.

In the blast furnace proper the engineers have designed a furnace which represents the best development in recent years with similar stacks built by them. The arrangement on the furnace top has been very materially improved as regards safety and convenience in work. The mantle and column has been increased in section and the manner of hanging the circle pipe, discharge trough and bustle pipe has been improved. An auxiliary cinder notch is provided. The iron and steel work of the furnace is so designed that the furnace can be enlarged at succeeding blasts if it should be found advisable. Other matters that are described later, but which should received particular mention, would be the evident care devoted to economy in quantity of concrete in the foundations, trestle approach, highway bridge and pig casting machine; and the new type of cantilever skip incline which affords greater rigidity of construction, and increased room in the cast house and on the furnace top.

Particular mention should be made of the improved gas main system which originated with Mr. D. T. Croxton. Contrary to the usual arrangement where gas mains are led overhead both at the boilers and stoves, the Trumbull-Cliffs gas mains are placed underneath or outside of the stoves and boiler house. At the stoves the large gas main from the gas cleaning plant goes to a water seal separator whence it is led along the piers of the skeletonized stove foundation. From this main pipes are led directly up through the stove platform to the stove gas burners. The main is given a slope which makes it easy to clean. On the boiler house side the large gas main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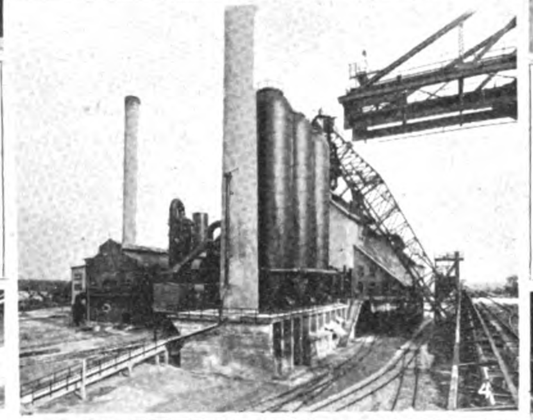
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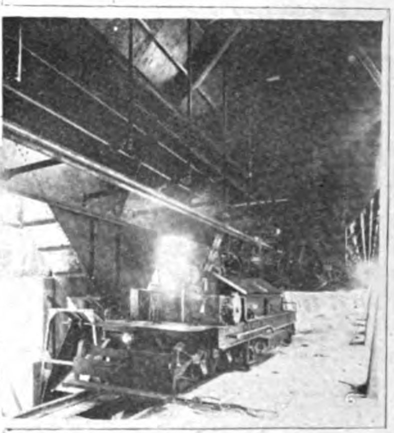
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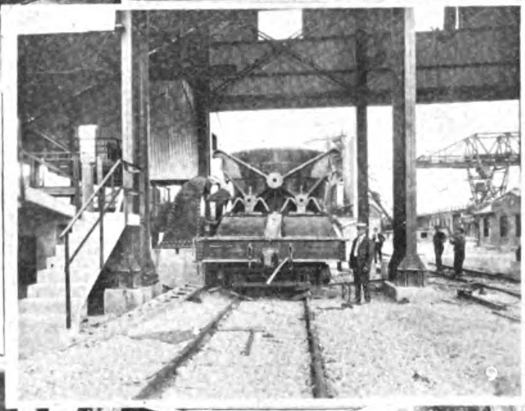
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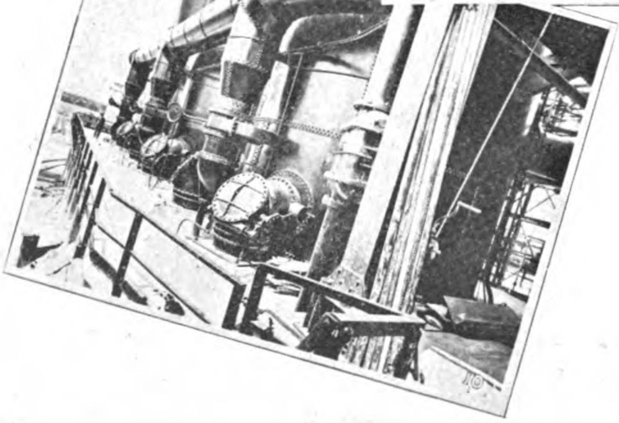
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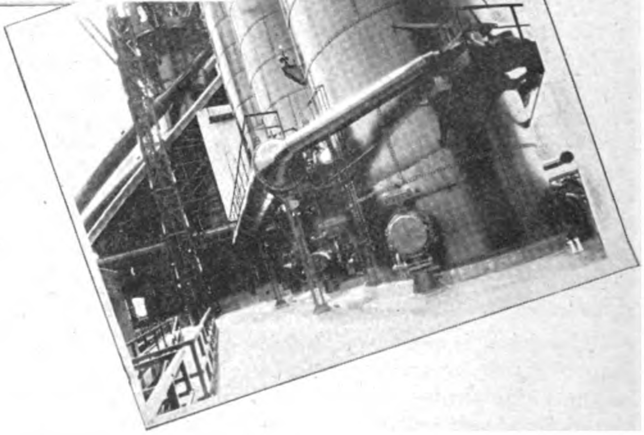

from the cleaning plant goes to a similar water seal separator whence it is led along at about yard elevation outside of the boiler house between the engine and the boiler house. This main is also given a slope and provided with downlegs for cleaning. From this main individual leads are taken to each boiler, the pipe for the gas burners coming up through the boiler house floor. This arrangement of mains is conducive both to cleanliness of the plant, ease in cleaning of mains and freedom from gas about the stove operating platform and inside the boiler house.

The grouping together as one unit of all elements of gas cleaning, the very complete maintenance and repair shop, and the excellent provisions made for the housing of the executive, general office, chemical and police departments should also be given special mention.

Starting in with the receipt of raw materials, the ore and limestone are unloaded by means of a Mead-Morrison movable car dumper. This dumper has a 57-ft. cradle and a capacity of 320,000 lbs. and is guaranteed to handle 30 cars per hour. The cradle is provided with both dynamic and air braking and has a travel the entire length of the ore and limestone yard.

Spanning the yard is a Mead-Morrison 11-ton man trolley ore bridge. It has a capacity of 600 tons per hour from the dumping pile to the storage pile or from the storage pile to the bins. The method of handling the ore and limestone consists in the movable car dumper placing material in a concrete dumping trough beneath the shear leg cantilever of the bridge. The 11-ton bucket picks up the material and delivers it to the main storage pile under the span of the bridge, or to the stock bins, or to the 50-ton Atlas transfer car when the materials being handled out of the stock pile are not directly in front of the stock bins into which they are being delivered.

The ore bridge has a cantilever at the shear leg end of such length as to permit delivery by the grab into railroad cars on the track approximately 32 ft. from the foot of the shear leg. This enables ore buckets to be changed and also enables the ore bridge to handle repair work at the car dumper. It has a similar cantilever at the pier leg end so that the ore bridge can handle the skips when they have to be replaced on the skip incline. The bridge has a travel speed of 70 ft. per minute and is of the skewing type, permitting either the shear leg or the pier leg to advance five degrees ahead of the other. It is completely equipped with safety devices to prevent over-travel of either leg, to prevent over-travel of trolley, and is equipped with magnetic solenoid brakes and rail clamps for provision against high winds.

The stock yard is 270′ wide by 505′ long and has a storage capacity for 250,000 tons of ore and 80,000 tons of limestone. Operating upon the ore bins is an Atlas 50-ton capacity side dump electric ore car, equipped with air operated brakes, doors and car pusher arm. The bins are provided with a cross-over and suitable conductors so that the transfer car can work on either of the two tracks on the bins.

The ore bins were designed and installed by the Hoover & Mason Co. They consist of nine ore pockets having a capacity of 3,120 cu. ft. each, four limestone pockets having a capacity of 2,900 cu. ft. each, and five coke pockets having a capacity of 2,900 cu. ft. each. In addition there is one central double compartment coke pocket, each compartment chuting coke to the skip bucket over a rotary grizzly screen. The rollers underneath the limestone pockets are perforated for screening.

The scale cars are Hoover & Mason double compartment type, equipped with air brakes, air operated doors and dial indicating and recording scales. Turn-out tracks for the spare scale car are provided under one part of the reinforced concrete trestle approach, the other part of the approach being bricked in to afford housing for riggers' tools, blast furnace spares, etc.

The control station for the skip hoist is on the yard level in proximity to the skip incline so that the skip operator has a view of the skip pit, as well as of the skip hoist track and the furnace top. The same station houses the control for the bell operating cylinders, the McKee distributor, the grizzly coke screens and the bell indicating and rodding devices. Connection is provided to the cast house and furnace top by speaking tubes.

The skip incline is of the cantilever type. It is supported entirely independent of the blast furnace so as to avoid any side thrust on the shell, and is 171 ft. 6 in. long with double track for skip cars of the trailer truck type. Skips are operated by a Lidgerwood electric double drum hoist, driven by a Westinghouse 200 hp d. c. motor. The hoist has a rope speed of 300 ft. per minute and is designed for an unbalanced load capacity of 20,000 lbs. Cutler-Hammer control is supplied. This hoist is located in a concrete and brick house under the skip truss and above the tracks. This structure also houses the bell operating cylinders which are actuated by air from the cold blast main. An auxiliary air supply is provided from the high pressure compressor line, and this is automatically admitted through a pressure regulating valve in the event of drop in the blast line pressure. The control board for the McKee distributor is located in this house. This control is for six-station, six-cycle operation, but provision is made for installation of additional panels for different cycles of charging.

The furnace top is of the standard double bell Freyn-Brassert design, having also a McKee distributor. The design of the receiving hopper and throat is worked out to give correct distribution even when the charge is not revolved. The entire top of the furnace has solid plate guard rails and special attention has been paid to accessibility of all working parts and for observing the distribution of material in receiving hopper and for observing the dumping point of skip. Bleeders are provided with permanent rail platforms, as is also the outrigger. The outrigger is provided with a trolley for facilitating work of repair or relining. Access to the furnace top is by means of interrupted flight stairs up the skip incline and also by means of a bridge from the furnace top direct to the Otis elevator, and by a bridge to the stove top. An extra large door is provided as the gas seal.

The six-passenger Otis elevator is a worm geared traction type, having a capacity of 1,500 lbs. load, fully equipped with interlocking devices and emergency safety features. It has push-button control and four landings.

The furnace is 92′x22′6″ and has a capacity of 25,500 cu. ft. The iron and steel work includes a heavy continuous cast iron sub-base. The concrete foundation is reinforced by tension bands and the column base and columns are encircled by a reinforced concrete beam, extending between the columns up to within a short distance of the hearth jacket segments. There are ten cast iron columns and ten tuyeres, tuyeres being placed centrally between columns, thus affording good working room. The columns are offset, which not only allows more room for work about the tuyeres and places the columns and col-breakout, but affords the possibility of enlarging the fur-

breakout, but affords the possibility of enlarging the fur-

nace hearth and bosh in the future. The columns are one piece and entirely free from any cast-on iron lugs. The bustle pipe, circle pipe and waste water trough are suspended from the mantle. Special attention has been given the location of circle pipe connections and waste water trough overflow so that there is ample room on the bustle pipe walk and it is free from obstructions. The hearth jacket is of the standard Freyn-Brassert cast iron segment design, having cooling pipe cast in, and heavily wedged, banded and bolted. It is tapered, thus maintaining a safe thickness of hearth wall against erosion and breakouts and also maintaining ample brick at the bottom to prevent short holes and to prevent the hearth block from rising. The tuyere breast consists of a solid armor of 1½" plates with openings for the 10 tuyeres and for the bronze cooling plates. The bosh is reinforced with eight 1½" thick bands, the bands being held by cast steel distance pieces to prevent slipping. The mantle is of a specially heavy built-up plate angle construction and is provided with a trough with drainage provisions for collecting shell spray water. The furnace shell, which is especially designed to meet modern furnace lines, is of butt strap construction on both the two bottom rings and the top ring. The intermediate rings are of double lap riveted construction. The shell is surmounted by a dome on which the large bell hopper ring is riveted.

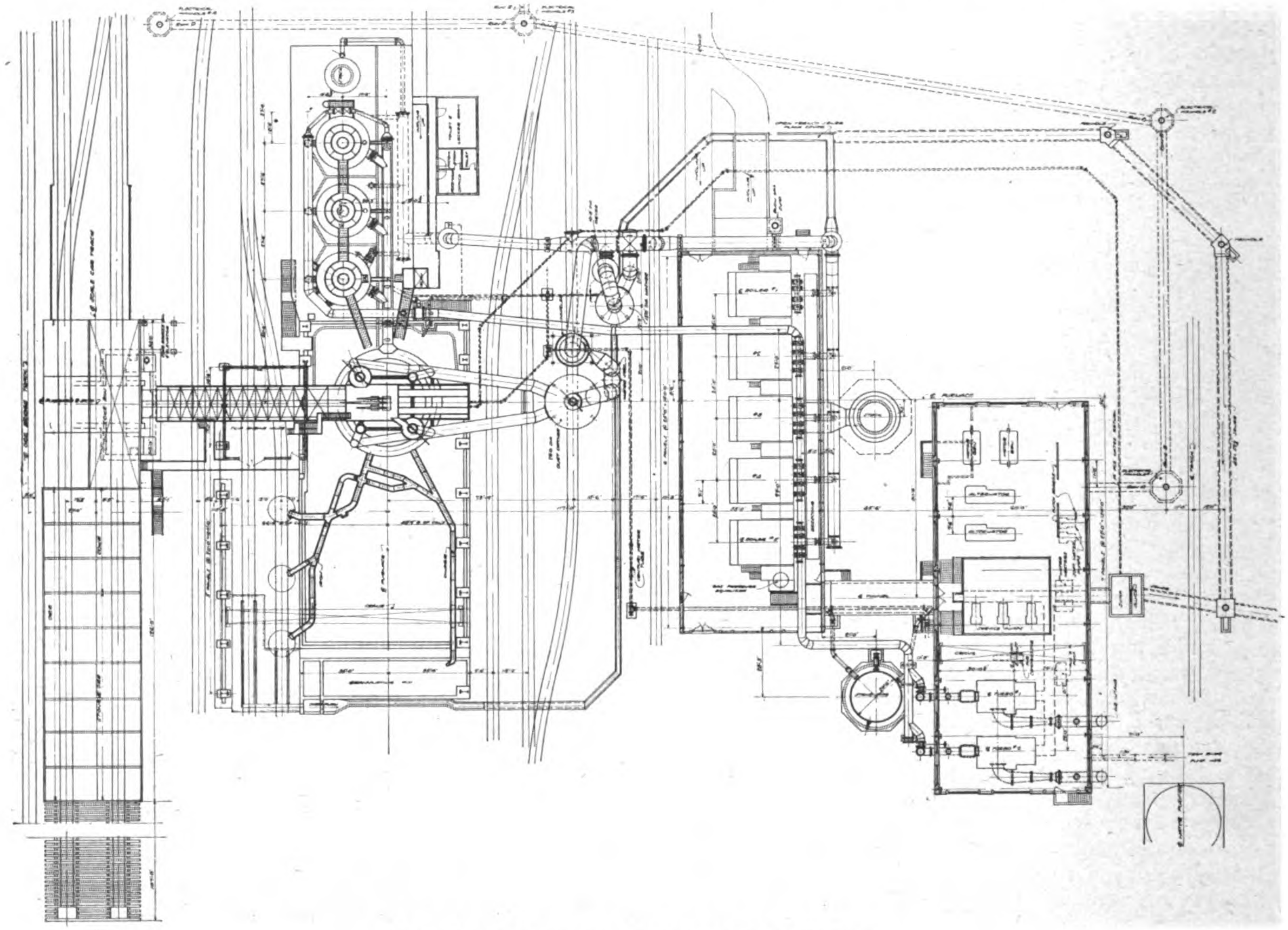

Fig. 12—General arrangement of Blast Furnace.

The furnace is lined with General Refractories Olive Hill steam pressed fire brick, the thickness of lining being heavier in the lower inwall, to afford maximum thickness where required, than in the upper part where an excessive depth of lining would be detrimental. No interior water cooling is given the lining above the mantle, but a permanent pipe spray with connection is affixed to the shell and a permanent platform is also provided at the spray. This platform is reached by a short bridge from the skip incline steps. A new design of bosh and tuyere breast plate is used, having baffles that give more positive circulation of water and enable the plate to be more easily withdrawn in the event of its becoming cracked or burned. The hearth walls are cooled by the cast iron cooling pipe of the hearth jacket, which extend approximately 9 ft. below the elevation of the tapping hole. The stock line is afforded protection by cast iron wearing plates of high combined carbon content. These plates are laid integral with the lining and are of small surface dimension in each unit.

The bustle pipe is insulated with Johns-Manville Vitro Fire Felt and easement against thrust against the columns by expansion of the hot blast main is provided in an expansion joint.

"Green" unlined tuyere stocks are used.

The hot blast stoves are three in number, with a total heating surface of 285,000 sq. ft. They are of the two-pass side combustion type of the standard Freyn-Brassert design. The stoves have a built in draft flue in the skeletonized reinforced concrete foundation, this flue leading to an 8'x225' Heine reinforced concrete stack, brick lined throughout. The stoves are equipped with blow-off valves turned down into the chimney flue, standard Freyn-Brassert equipment of quick closing chimney valves, gas burners and gate type hot blast valves. Provision is made for the future installation of an additional hot blast stove. These stoves have 3½" checkers with 2" checker walls, the design of checkers, arch and draft chamber equalizing the flow of gas down through the checkers, thus overcoming the usual tendency toward segregation of flow of gas in a limited number of checker openings. The stoves are insulated with Sil-O-Cel powder and brick and are lined with General Refractories fire brick; hand made inwall quality is used in the combusiton chambers and dome, and steam pressed inwall quality in the top of the checkers. The ring wall and bottom of checkers as well as draft chamber piers and arches are made of stove quality. The gas main leading to the stoves is equipped with a butterfly valve which is intended later on to attach to a new Freyn-Brassert design of gas pressure equalizing equipment to maintain constant pressure in the stove gas main.

The cast house, which is on the same elevation with the hot blast stove operating platform, is laid out to run cinder either to cinder ladles or to a cinder pit at the foot of the cast house. The iron runners are laid out to deliver to three 75-ton Pollock short-pour hot metal ladles. The runners have a fall of ⅝" to the foot to give a minimum amount of scrap. Coke dust, sand, loam, clay, furnace tools, copper, etc., are brought to the cast house, and the 25-ton crane, spanning the cast house, the hot metal track adjacent to the retaining wall of the cast house, and the working track outside of the hot metal track. The materials are placed in a permanent brick and concrete shed inside of the cast house. The equipment of the cast house includes a Berg-Brosius clay gun, which was specified not only as a safety measure but also for the purpose of keeping the blast on the furnace and gas on the boilers over casts. The working cinder notch is 45 degrees from the iron notch. An auxiliary cinder notch is provided, this being fitted up with a standard cooler and intermediate cooler so that cinder can be withdrawn here in an emergency. The shutters are all of the Fraser remote control type, and snort valve wheel, mud gun control and shutter control are all located at one point. Special lighting facilities have been provided and there are an abundant number of hose connections for both high and low pressure water. Steam and air are piped to the cast house for use on mud gun and for other casual requirements. For the purpose of communication there is a speaking tube from the cast house to the nearby operator's house and to the furnace top, and there is also a duplex signal apparatus connecting the cast house with the boiler house and power house.

The gas is taken off the furnace by four offtakes from an annular space about the big bell hopper, which reduces the average gas velocity and reduces the production of flue dust. These four offtakes lead to four uptakes, two of which are surmounted by Baer safety explosion valves. The uptakes lead into four downtakes, each two combining into one downcomer. The two downcomers enter the dust catcher radially.

The gas cleaning system is located between the boiler house and the blast furnace. It consists of one 22'x40' dust catcher for primary cleaning of gas. The gas is then led to a 12'6" Brassert tangential whirler where further amounts of fine flue dust are removed. From the whirler the gas is led through a series of goggle valve by-passes so arranged that the gas can be handled in a variety of ways. It is contemplated to run—and the system is thus arranged—so that all the gas is led through the Brassert gas washer, thence through a water seal separator to the main leading to the hot blast stoves and to the boilers. If desired, only the stove gas may be washed and gas sent from the whirler direct to the boilers, or in an emergency rough gas may be sent to both stoves and boilers. All these gas cleaning elements are located in one unit, completely equipped with platforms, thus making easy their supervision and care, and are standard equipment that have been used on upwards of 90 installations embodying well worked out means for obtaining gas with not to exceed 0.2 grains of dust per cu. ft. The washer is of the latest type of Brassert washer and has a novel arrangement of sprays which produces a large mass of spray having an intense whirling action. Not only is there an appreciable economy effected in the use of water, but the washer handles and cleans dirty gas even better than heretofore. To eliminate the nuisance of dust, which has always been such an annoyance at blast furnace plants when the dust catchers are dumped, Mr. D. T. Croxton has evolved an arrangement which will deliver the dust from the dust catcher and whirler to the cars in a moist state. This consists of a Bartlett-Snow double screw enclosed conveyor which is attached to the dust catcher by means of a special screening casting. The dust flows through this screen and falls into the first stage of the double screw conveyor. This conveys the dust down into an enclosed trough of water and delivers it to the second screw conveyor which again lifts the dust out of the enclosed trough and delivers it to the car. The dust in passing through the double screws submerged in the trough of water becomes thoroughly pugged and saturated with moisture. The coarse materials that do not pass the screen leading to the pug mill go to the bottom of the dust catcher where they are removed by occasional dumping of the main dust catcher bell. In an emergency the entire contents of the dust catcher may be removed in the usual way.

The gas main system consists in branches from the gas cleaning plant to both the stove and boiler gas mains. At both the stoves and boilers water seals are provided; in addition a further complement of water seals is installed so that the stoves or boilers may combinedly cut off from the entire gas cleaning system at cast or shut down, so that the wet cleaning system may be isolated from the dry cleaning system, and so that the entire system may be isolated from the furnace. These water seals are provided with large capacity lines so that water can be admitted and the seals filled in a very short time.

The blast main system starts at the turbo blowers. The discharge from the turbo blower is provided with an Ingersoll-Rand multiple port disc check valve. Motor operated cold blast valves are provided outside of the power house building. The cold blast main leads directly to the hot blast stoves, being provided with two counterweighted blast relief valves and the usual snort valve. The snort valve discharge is turned down into the stove flue. The by-pass leaves the cold blast main at its end and leads around No. 3 stove, entering the hot blast main at the extreme end from the furnace. It is provided with a McCarthy check and regulating valve.

The boiler house is 150 ft. long by 55 ft. wide and 43 ft. high. It is of brick and steel construction with corrugated steel monitor type roof. All window sash is of steel, Truscon type, glazed with factory rib glass.

There is provided 4,000 hp in units of 800 Class "M" Stirling four-pass boilers, built for 231-lb. pressure and 125 degrees superheat. All boilers are gas fired, being

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equipped with four improved 14" Birkholz-Terbeck burners. These burners are placed at the rear of the boiler under the mud drum, the mud drum being set at an elevation of 10 ft. to provide large distinct gas combustion chamber. The burners are provided with means for removal of cone for cleaning. Control of gas at the burners is by means of butterfly valves on the individual legs to each burner, and shut-off of gas is by means of one large gate valve in the main leading from the large boiler house gas main outside of the building. In addition this main can be filled with water to form a water seal valve, thus safely isolating any particular boiler when it is to be entered for cleaning or repairs. The boiler house gas main itself is outside of the building at yard level, and dust removed from the main is washed through a concrete trench direct to the sewer. The main has an auxiliary bleeder at its end as does also the stove gas main.

The boilers have provision for auxiliary coal firing, being equipped with Marion shaking grates. Coal is brought into the boiler house by means of a track hopper which discharges onto a Jeffrey belt conveyor. This conveyor was used in the construction work for handling brick and has been reinstalled at the boiler house to eliminate the large amount of hand labor usually employed in unloading coal. This Jeffrey belt in turn discharges to a Weller Manufacturing Company shuttle conveyor which runs along inside of the boiler house, by means of which coal can be discharged to any point along the boiler house floor. There are ash hoppers attached to the ash pits of each of the boilers. These hoppers are provided with gates at such elevation in the boiler house basement that a large truck can run beneath the hoppers. There is provided a concrete runway from yard elevation down into the basement floor of the boiler house, and ashes will be dumped direct from these hoppers into an auto truck and used for fill on the property.

The boiler draft requirements are furnished by a 225'x12'6" reinforced concrete stack built by the Heine Chimney Company, brick lined throughout. The boilers are connected to this stack by an insulated steel breeching. Other equipment in the boiler house consists of Williams feed water regulators and Babcock & Wilcox bare tube superheaters. The boilers are substantially built with particular reference to resisting gas explosions, and the front so constructed that by addition of a Dutch oven any standard type of stoker can be placed in the boilers in the event either of expansion of the plant or desire to generate additional electric power with the existing unit. The boilers are placed singly, right and left settings, 6' aisles.

The boiler feed water is normally taken from the service water mains of the blast furnace plant, it being delivered under standpipe pressure to the We-fu-go water treating system installed by Wm. B. Scaife & Sons Co. This is an intermittent cold process having a capacity of 20,000 gal. of water per hour. From the We-fu-go system a 500-gal. capacity pump, provided with a spare, pumps water to two Cochrane 4,000-hp open type feed water heaters. From the heater water is delivered to the boiler feed pumps. These are 4" four-stage double suction 500-gal. 600' head Worthington pumps, driven by Terry turbines. From the boiler feed pumps water is delivered to the boilers by means of an insulated boiler feed line. An auxiliary boiler feed line is also provided for emergencies. The two centrifugal boiler feed pumps are supplemented by a Worthington Duplex 500-gal. 300-lb. head reciprocating pump, which is connected up so that for normal operation it can furnish high pressure water for fire service, or at the top of the furnace, or around the blast furnace and cast house for flushing, cooling copper, etc. All these pumps are in the power house basement and one operating suffices to take care of the boilers.

The boiler house is laid out to permit expansion to the south for additional boilers, additional blast furnace units and coke ovens.

The power house, which is 154 ft. long by 60 ft. wide by 33 ft. from first floor, 18-ft. high basement, is also of brick and steel construction. Particular attention was paid to day lighting and ventilation. The blowing equipment consists of two Ingersoll-Rand turbo blowers. The air blower has five stages and the steam turbine seven. These blowers have a nominal capacity of 45,000 cu. ft. of air per minute at 30-lb. pressure, and will blow 55,000 cu. ft. of air per minute at 22-lb. pressure. The turbines are of new Ingersoll-Rand design, having but two steam admission valves, one for normal load and one for overload. The regulating device is also of an improved type, consisting of a single venturi instead of the old type of triple venturi. The single venturi is not so sensitively affected by leaks in the intake line, nor by dust or dirt in the air. There is a separate air intake for each blower which is led up to a considerable distance above the power house roof. Recording gauges are provided on each intake to record the amount and regularity of blast volume blown.

Electric power is generated in either of two Allis-Chalmers 1250 k. v. a., 80% p. f., 2300-volt, 3-phase, 60-cycle 3600 r. p. m. turbine generators equipped with direct connected exciters. A portion of this power is transmitted to the river pump house at which there are installed three 250-hp 2300-volt, 760 r. p. m. induction motions driving the centrifugal pumps. These motors are of the wound rotor type and are equipped with primary oil switches and secondary drum control, electrically interlocked. The motors were furnished by the Allis-Chalmers Manufacturing Company and the control switchboard was assembled by the engineers from parts furnished largely by the Westinghouse Electric & Manufacturing Co.

The bulk of the electrical power required at the plant is d. c. and to furnish this there were installed in the power house two Allis-Chalmers 750-kw, 720 r. p. m. motor generator units, supplying direct current at 250 volts. The driving units are 1160-hp 220-volt synchronous motors, excitation being taken from the d. c. units. The synchronous motors are started from auto transformers at 33% voltage in order to minimize the starting demand on the generator units. The power house switchboard contains 16 panels divided into an a. c. section of eight panels and a d. c. section of eight panels. The arrangement is such that future additions may readily be accommodated.

The a. c. switchboard is of the remote electrical control type. The oil switches are mounted in the rear of the board, liberal space being allowed for access. Of particular interest perhaps is the arrangement of a plug switch on each a. c. panel connecting with the power factor meter, thereby enabling the total power factor to be determined as well as the power factor of the individual generators, synchronous motors and feeders.

The d. c. feeders emanate from the power house direct to the car dumper and ore bridge and also to a distribution center at the blast furnace. Here the skip hoist, transfer car and scale cars, coke braize system, and cast house crane are fed. Another feeder terminates in a dis-

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tribution center at the pig casting machine, from which the strand drives and ladle house crane are fed. The machine shop, office and power house auxiliaries are fed from the distributing panel of the power house switchboard. The greater portion of the electrical distribution is underground, liberal duct space being allowed for future growth of the entire system. The transmission to the river pump house was installed overhead for the reason that a portion of this line passes through territory subject to flooding. Duplicate feeder panels and feeders are supplied for this line to ensure continuity of service and to further protect the primary service pumps provision is made for connection to the Trumbull Steel Company across the river.

The lighting system for the plant is exceptionally complete and effective. A three-wire 115-230-volt system is installed. There are two transformers at the power house, one at the skip hoist and one at the pig casting machine. In case a transformer burns out, one of the units at the power house may be utilized for replacement and the lighting in the power house district temporarily reduced. Wherever necessary lamps are protected from moisture; all lamps have suitable reflectors and all inaccessible lamps have disconnected hangers. There is furthermore installed an auxiliary lighting system for emergency use, this being supplied from the exciter bus. The power and lighting installation is of exceedingly high type and safety for the men is provided in the shape of Leonard safety switches installed ahead of all starting and control equipment. Every detail has been arranged and installed in a most thorough manner.

Steam lines for the plant are in duplicate, consisting of a large main header having capacity for the entire steam demands of blower, generator, pumps and auxiliary machinery in the power house. This is supplemented by another header tied in at four points so that in the event of replacement of any fitting or gasket on the main header, a sufficient number of boilers can be tied to the power house, cast house and pig machine operation. This auxiliary line has sufficient capacity to run the blower and pumps with some reserve for partial load on the generator. The main steam lines are carried on brackets in the boiler house up to the tunnel which connects the power house and boiler house, where they are led direct to the power house. This same tunnel also serves for the boiler feed lines, high pressure water lines, service water lines and electric conduit, and is the regular means of communication between the power house and boiler house. All steam lines to blowers and turbines are underneath the main power house floor, thus presenting a very neat appearance. Steam lines and boiler feed lines are all covered with 85% magnesia insulation and have a very adequate equipment of drains and separators. The existing lines, inclusive of the main steam header in the boiler house with its lead to the power house, from the first element of the eventual power and boiler plant, when the header will expand into a complete loop system with additional cross connections between the power house and boiler house.

The power house is served by a Cleveland Crane & Engineering Co. 15-ton 4-motor crane, having 5-ton auxiliary hoist. Other equipment in the power house consists of a Worthington steam driven air compressor having capacity of 300 cu. ft. of free air per minute; the double Cochrane feed water heater; a 100-gal. Worthington reciprocating pump that pumps treated water to the offices for washroom and laboratory service; two 5" 500-gal. motor driven water circulating pumps delivering water from the water treating system to the heaters; and a set of Richardson-Phenix continuous by-pass turbine oil filtering system units. All of the equipment in the power house excepting the turbo blowers, turbo generators, motor generator sets and the switchboard, are housed in the basement of the power house, where in addition are the three 10" 4500-gal. 158-ft. head 1900 r. p. m. Worthington centrifugal pumps which pump the water for the plant use. These are driven by Terry turbines. The exhaust steam from the service pumps, from the boiler feed pumps, from the office water pump and from the compressor, all exhaust to the Cochrane feed water heater. In the basement are also the condensers for the turbo blowers and generators. There is provided at each blower an Ingersoll-Rand low level multiple jet condenser, and at each of the turbo generators there is a similar low level multiple jet condenser. These are installed for 28" vacuum and due to the design of the condenser no air removal nor water removal pump is required. Both the turbine floor and auxiliary basement floor present a very neat appearance, there being ample room and entire absence of pipe interferences.

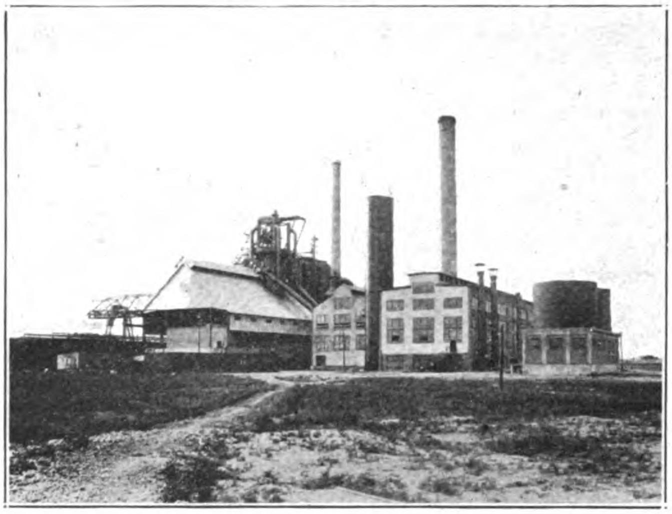
Fig. 13—General view of the plant.

The water system of the plant deserves particular mention as considerable economy is effected in the use of water, at the same time retaining the very desirable element of simplicity of circulation and furthermore obtaining the possibility of using different sources of water at many points in the event of failure of any particular source.

The water system starts in at the river pump house which is of novel design in that considerable space is saved, consequently eliminating considerable concrete and excavation work. The suction well for the pump is inside of the pump house, water being led from the pool outside into the tunnel though two 72" link-belt vertical traveling refuse screens. These are fitted with ⅜" screens and driven by 5-hp motors.

In the pump house are installed three 12" 6,000-gal. 115-ft. head Worthington pumps, motor driven. Two of these pumps operating deliver water to the turbo blower and to the turbo generator condensers. Tail water from the condensers is led by means of a weir to a sump running lengthwise of the pump basement. From this sump the three 4,500-gal. Worthington service pumps, two operating draw their supply and pump through a 20'x120' standpipe located between the power and boiler house.

This standpipe in turn delivers water to the blast furnace, cast house, hot blast stoves, cinder pit, gas washer, pig casting machine and water purifying plant, together with all other miscellaneous uses. The flexibility of this system may be appreciated by stating that the lines are so arranged that, if desired, the standpipe can be bypassed altogether or it can be used simply as a floater on the service line, no water being actually pumped through it. Safety provisions are adequately taken care of by connecting the line that leads from the river pumps to the condensers to the service water line into which the power house service pumps discharge. In the event of these pumps for any reason being out of commission, the river pumps have sufficient head to keep water on the blast furnace bosh, stoves, water seals and to supply water to the feed water treating plant, thus assuring a supply of water that will prevent damage or serious accident. A further safety provision is afforded in having this same by-pass line from the river pumps discharge, if desired, into the sump from which the basement service pumps draw their supply. This may be found useful in case the condensers have to be taken off. A further safety provision is found in an ingenious method of returning the bosh water. The overflow water from the furnace is all conserved and led by means of a separate pipe line back to a cistern at the extreme end of the basement sump. As long as the level of water in the basement sump is kept up to the mark by the water coming from the condenser tail water pits, then the return water from the furnace overflows into the sewer and back into the river. However, if the amount of water coming through the condensers and thence to the sump should for any reason be deficient, then the return water from the blast funace runs into the sump from which the service pumps pull their supply. Under normal conditions of operation there is about a 40% surplus of condenser tail water going into the sump over and above the amount of water required at the plant exclusive of condensers. To still further safeguard the plant supply of water the lines of the standpipe are equipped with check valves which will prevent the standpipe from emptying in the event of a break in the line. A final safeguard at the furnace is found in the provision of check valves in the two distinct water supply lines leading to the circle pipe. Between the circle pipe and these check valves is connected a line from the Worthington high pressure pump and inasmuch as this is in normal operation continually kept floating on the high pressure line, then in the event of failure of lines or service pumps the furnace bronze can be preserved by opening up the line admitting high pressure water to the circle pipe, the check valve preventing escape of this water back into the main service water line. This high pressure water is similarly piped up to the stove fittings and to the main isolating water seal valve, and in an emergency the high pressure pump can draw its supply of water from the standpipe which, in the event of a very bad accident or breakdown at the pumps or lines, would still remain full of water. It will be seen that the plant is assured of a supply of water that will last almost indefinitely in an emergency by virtue of the provisions for recirculation of water.

The boiler feed pumps similarly have a triple source of supply. Normally they take from the feed water heater. In emergency they also draw from the basement sump, from the blast furnace service water lines or from the line leading from the river pumps to the condensers. The turbines similarly draw on two sources for their supply of cooling water, i. e., the service water supply line and the condenser water supply line.

In addition to the link belt traveling screens at the river pump house, the lines are further provided with Elliott twin basket strainers at both of the supply lines to the furnace circular pipe and to the stoves, and also at the line leading to the gas washer. The boiler feed line, the gas washer line and the furnace supply water line are provided with venturi meters.

A tank is provided at the machine shop to which treated water is pumped from the power house basement for the use of the yard locomotives.

The sewerage system is very largely an open one, this type being decided upon on account of the many unfortunate experiences with closed sewers about blast furnace plants where so much rubbish, such as graphite, granulated cinder, etc., is liable to plug the sewers. Specal pains are taken at the cinder pit to avoid escape of granulated slag into the sewer system, there being provided a settling basin and submerged weir to prevent as much as possible the escape of cinder. The overflow water from the pit runs through a screened open sewer to the sump beneath the gas washer. Here the cinder pit water joins the discharge from the gas washer and is led in an open sewer to the boiler house. A sewer, which carries off ash-up water and also the drainage water from the hot blast valve fittings is led from the furnace and stove foundations to intercept the main open sewer. At this point the sewer runs underground a distance of about 500 ft. through 48" reinforced concrete sewer furnished by the Massey Concrete Products Corporations. The boiler house and the trench underneath the gas main in the rear of the boiler house are drained into this sewer. As it passes beyond the corner of the power house it emerges again into an open sewer which is led down to the river. Into this sewer also drains the surplus condenser water; any surplus bosh return water, and the drainage from the power house basement. The sewer is of ample capacity to handle all surplus and waste water as well as storm water about the plant.

Hot metal is normally shipped to the mixer of the Trumbull Steel Company, but there is also provided for the casting of chill iron a double strand pig casting machine. This is standard Heyl & Patterson equipment having manganese links and pins. The pig machine strands are mounted on a reinforced concrete structure. This type of construction was oiginated at the blast furnace plant of the Otis Steel Company and was chosen because of elimination of deterioration encountered with structural steel supports by reason of the large amounts of steam and water about the operation. The concrete structure provides a continuous platform under the strands, makes for an easy replacement of molds, and provides a channel for spray water which is carried into a sump at the pouring end. The length of rails is limited to 11 ft. to make a convenient length for handling when replacements are necessary. All castings used in connection with the machine and in connection with the structure can be replaced with open sand castings poured at the cast house of the plant. The machine is laid out for additional strands with the growth of the plant. Integral with the pig casting machine is a combined ladle and pouring house. In this is a 55-ton Morgan pouring and ladle handling crane having 100% overload capacity. This serves both to pour the ladles by means of the patented Pollock short pour device and also serves for removing the ladles from the trucks for relining. A spare ladle is provided to be held in reserve for lining.

Considerable study was given the location of the track scales and these were so located that they serve admirably both for the light and heavy weighing of pig iron cars as well as for check weights on receipt of raw material into the yard. A well designed scale house is noteworthy, in which is also incorporated the yardmaster's office, locker rooms for train crews and washroom facilities. The facilities at the scale house office are supplemented by a larger locker and service room for the furnace men located in proximity to the incline leading from yard level up to the furnace and stove foundation top. Additional toilet and locker rooms are located in the basement of the power house and boiler house for the men, and at the machine shop.

Provisions for repair and maintenace of the plant and its equipment are all grouped in one large central machine shop building. In the center bay of this building is the machine shop proper which is arranged for a traveling crane spanning a very complete complement of machine tools adequate to machine and repair all parts of equipment and castings going into the construction or repair of the plant. There are two lean-tos which house the chief engineer's and general master mechanic's office, and which also have the pattern shop, electrical shop, pipe fitting shop, blacksmith shop and storeroom. The storeroom for large castings and bronze parts is in a bricked-in house under the trestle approach and the storage for rigger tools is in a similar brick house. The general administrative and executive offices are in a large well designed building at the plant entrance. Here is placed the general superintendent's and his assistant's office, the office of the chief clerk and the timekeeping, distributing and clerical force, the laboratory, police and employment offices, and the cafeteria.

The quantities of material used in connection with this job are of interest. There were placed 2,246 20′ to 30′ Raymond reinforced concrete piles; a total of 61,974 cu. yd. of excavation; 31,601 cu. yd. of concrete; 224,365 cu. yd. of fill; 750 tons of reinforcing steel; 1,270 tons of plate; 729 tons of castings; 145 tons of structural shapes; 65 tons of forgings; 1,251 tons of structural steel in buildings 1,020 M building brick; 2,083 M fire brick, and an average of 371 men were employed per day for the 10 months' period of construction.

The contractors engaged in this work were as follows: Fabrication and erection of iron and steel work other than structural, the William B. Pollock Company; fabrication and erection of structural steel in buildings and skip incline, Lackawanna Bridge Company and Hill Clutch Company; Phenix Iron Works and the Pennsylvania Engineering Works furnished some of the iron and steel castings. All brick work in furnace, stoves, boilers, power house and offices was placed with the P. J. Brown Construction Company; the concrete was put in by Arthur G. McKee & Co.; car dumper and ore bridge, Mead-Morrison Manufacturing Company; ore bins and scale cars, Hoover & Mason. Piping was installed by B. Floersheim & Co. Instruments for the blast furnace and power and boiler houses were supplied by The Bristol Company. The Trumbull-Cliffs Furnace Company, in the person of Mr. J. S. Fraser, works manager, and Mr. O. C. Callow, electrician, supervised and directed the placing of most of the equipment wiring and switchboard.

The construction of the plant was directed by the organization of the Cleveland-Cliffs Iron Company through Mr. D. T. Croxton, manager of their pig iron sales department. The plans and specifications for the complete plant and plant equipment were drawn up by Freyn, Brassert & Co., Chicago. These engineers also had supervision of construction, Mr. Roy W. Clark being chief resident engineer, for the firm.

The Trumbull-Cliffs Furnace Company, through its executive and its superintendent, coöperated with the engineers in all details of planning the work, in purchase and delivery of materials, and in expediting the work in the field.

On completion the Trumbull-Cliffs Furnace Company held "open house" and the plant was visited by a large number of executive and operating officials of the iron and steel plants of the country. The many features and the remarkably quick time of construction have been the object of much favorable comment and the Trumbull-Cliffs Furnace Company is not only to be commended for the opportunity it has given the men in the industry for personal inspection of the plant, but is also to be congratulated upon the ownership of a plant that represents such a conservative and successful application of sound operating and engineering features.

QUESTIONS AND ANSWERS.

Question recently submitted to the Blast Furnace and Steel Plant.

"What is the cause of negative brushes pitting and the positive brushes picking copper on a D. C. generator 800 kw. 83 rpm. 3,200 amps? Machine is not overloaded.

Answer: The condition experienced above is in the nature of an electralytic action. Where the electric current flows from one surface to another, there is a tendency for small particles from the substance out of which the current flows to the other conductor.

Thus in a generator, negative brushes are eaten away and the carbon in some cases deposited on the surface of the commutator causing it to blacken.

If the action is more severe, copper is taken away from the commutator and deposited on the positive brush, and the commutator takes on a bright surface but does not polish.

This action is due to too high current density under the brush. This may not necessarily mean that the load current is too high, but rather that the short circuit current—due to improper commutation of the voltages generated by the process of commutation is excessive.

This may be caused by improper brushes, wrong and gap between armature and interpole, saturation of the interpole circuit, interpoles not properly adjusted as to the ampere turns, and brushes not on the electrical neutral.

This action will also be noted on revolving field alternators, where one ring becomes very rough and is eaten away while the other ring takes on a bright polish.

This action also comes into play on the slip rings of rotary converters, causing them to become eccentric and the brushes to chatter.

This explains why brushes should be staggered in pairs and not alternately. In staggering brushes alternatively the positive brushes will run in the same track, thus grooving the commutator.

A large majority of comutator wear is due to this and not to the abrasive material in the brushes as often supposed.

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Steel Plant Electrical Engineers Convention

Association of Iron and Steel Electrical Engineers Hold Fifteenth Annual Convention in Chicago—Many Valuable Technical Papers Are Presented—Interesting Exhibit of Electrical Equipment for Steel Plants.

THE Fifteenth Annual Convention of the Association of Iron and Steel Electrical Engineers was held in Chicago, September 19th to the 24th. The headquarters being at the LaSalle Hotel and the sessions and exhibits on the Municipal Pier. About one thousand members of the Association attended the Convention.

Technical papers were presented by well known men of the steel industry, among whom were:

R. B. Gerhardt, Electrical Superintendent,
Bethlehem Steel Company, Sparrows Point, Md.
R. D. Cousins, Electrical Engineer,
Illinois Steel Company, Gary, Indiana.
G. R. McDermott, Assistant Engineer,
Illinois Steel Company, So. Chicago, Ill.
W. N. Flanagan, Steam Engineer,
Ohio Works, Carnegie Steel Company, Youngstown, Ohio.
F. B. Crosby, Electrical Engineer,
Morgan Construction Company, Worcester, Mass.
A. C. Bunker, Electrical Engineer,
Crocker Wheeler Company, Ampere, N. J.
A. M. MacCutcheon, Designing Engineer,
Reliance Electric & Engineering Co., Cleveland, Ohio.
E. T. Moore, Electrical Engineer,
Halcomb Steel Company, Syracuse, N. Y.
F. W. Cramer, Engineer of Tests,
Cambria Steel Company, Johnstown, Pa.

Abstracts of several of these papers are given in this issue of "The Blast Furnace and Steel Plant" magazine.

The exhibits were very interesting. Practically all the large electrical manufacturing firms were represented. The social end of the Convention was very well taken care of.

One particularly interesting paper was presented by F. B. Crosby on "The Electrical Engineer in the Steel Plant and Out." During the course of his paper Mr. Crosby said:

We are so often reminded that "This Is an Age of Specialization," it may be hardly necessary to again emphasize the fact that never in the world's history has the demand been as insistent as it is today for men skilled to a degree possible only to the intensively trained specialist. This demand is not a passing fad or fancy, but is rather the direct result of necessity.

In all ages there have been those who, by virtue of unusual talents, inherited or acquired, have stood head and shoulders above their fellow workers. It is probable that even in those far distant days when man first began to exercise the power of reason, and thus began his never ending divergence from the lower forms of life, it was noted that certain individuals of the tribe could more effectively fashion clubs, hatchets and arrow heads, while others were more proficient in the use of these crude implements of warfare and the chase.

The maker of arrow heads did not possess, nor did he have the ability to acquire, the skill of his brother in the chase. He remained, therefore, in his cave busy at his own craft producing a supply of arrow heads to exchange for a portion of the necessities and luxuries of existence accumulated by his more strenuous brother.

What is more natural, then, than that there should have come into existence, even in the early dawn of human progress a partial segregation of labor and a system of barter which, in its essentials, bore the same relations to the average intelligence and needs of the individual as do our great productive enterprises to the keener intelligence and more comprehensive requirements of today.

As the race merged from a state of savagery its wants became increasingly diversified and the maker of stone arrow heads became the maker of implements of wood and bronze. The variety of products demanded of him became so great that he could no longer construct all with equal facility, consequently he quite naturally devoted his attention chiefly to those articles which he could produce better and quicker than his neighbor, and thus assure to himself a profit from his labor. So we have another step in the segregation of industrial activities as a logical sequence of the progress of mankind.

Our primitive ancestors recognized, with reason scarcely to be differentiated from instinct, certain fundamental economic principles which we with all our boasted advantages of civilization are too apt to disregard or completely lose sight of.

The comparatively early appearance of the religious motive inherently characteristic of all mankind gave rise to a priesthood which for many centuries seems to have developed and concentrated within its own jurisdiction all existing knowledge of metaphysics, engineering and what is now referred to as "pure science." The ancient Aztecs and Egyptians must have possessed a knowledge of mathematics and astronomy almost unbelievable, in view of their apparent lack of our modern aids in this field of research. The Aztec calendar, carved in stone and still in existence, provided at least 50 per cent greater accuracy in the measurement of solar time than does the Gregorian Calendar

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Included in the report of this meeting are abstracts of several of the papers read. Complete papers may be secured from J. H. Kelly, Secretary, Association Iron and Steel Electrical Engineers, Pittsburgh, Pa.

produced many centuries later, and now in general use throughout the civilized world.

Such marvelous achievements as the Egyptian pyramids, the hanging gardens of Babylon, the unsurpassed architectural features of the stone temples in the Peruvian Andes and of the Aztecs in ancient Mexico, are silent but commanding witnesses to the master minds which conceived them and directed their construction. Who can say but that these ancient works will continue to stand for untold centuries after the greatest of our modern engineering enterprises return to dust and the great nations of the present times are but a fading memory?

In reviewing the work of past generations, one always finds the specialist. He has ever been an essential factor in the intellectual and aesthetic as well as the industrial life of all peoples. His functions have been identical in character and have changed only in degree. Every age has had its great artists, sculptors, writers, philosophers, executives and skilled craftsmen. Many of these have been great not only when measured by standards of their own day and environment, but by the standards of all time.

With the introduction of the age of steam and electricity came unprecedented improvements in transportation. With almost unlimited facilities for personal communication and interchange of ideas through the media of telegraph, telephone and modern press, the sum total of human knowledge has increased more rapidly than has the mental capacity of the individual for assimilation of this knowledge.

The average level of human experience and knowledge is rapidly rising, and at an increasing rate. The inability of the finite mind to grasp the infinite or even that infinitesimal portion represented by classified knowledge has compelled an attention to detail on the part of the present-day business or professional man which, in too many instances practically precludes more than a superficial acquaintance with other equally essential activities.

And so we find a logical basis for our major premise; that today is the day of the specialist whether it be in politics or business, in the field or art and letters or in the professions of law, religion, medicine or engineering.

The day of the Jack-of-all-Trades, an extremely valuable member of society in pioneer life, is rapidly giving way to the man whose motto is "To know everything about some thing and something about everything."

This condition of affairs is by no means an unqualified blessing; in fact it possesses certain very undesirable not to say dangerous possibilities.

The electrical engineer is a much younger but very lusty offshoot of that fraternity so long composed chiefly of mechanical, civil and mining engineers. It is but forty years since the Edison bi-polar of 16 incandescent lamp capacity represented the climax of electrical achievements, yet in that short time the electrical industry has grown to the marvelous proportions with which you are familiar.

We have long since reached the point where to be known as an electrical engineer is not sufficiently distinctive. In no other of the several main branches of engineering has the necessary and continuous subdivision of duties been so marked. A general knowledge of the fundamental laws of electricity and magnetism is essential in all cases, but today we must have the specially trained electrical expert; one, for example, who shall concentrate all his efforts on the design of motors, and not merely motors, but alternating current motors, and still further a specific type of alternating current motor; another on certain types of generators; another on transformers; another on switchboards; another on magnetic control; another on station layout; another on transmission systems; another on application and operation of all these. We must, also, have the telephone engineer, the signal engineer, the illuminating engineer, the electrochemical engineer, and so on without end—and yet they are all electrical engineers; each in the daily routine of his highly specialized effort is absolutely dependent upon the separate and combined efforts of all the rest.

This interdependence and necessity of close cooperation must be emphasized. Any attitude of jealous exclusiveness within engineering bodies which should and do have so great a community of interests as do the American Institute and the A. I. & S. E. E. is greatly to be deplored. The functions of these two associations make contact at many points and in some instances overlap, but as a whole they certainly are not super-imposed. The A. I. E. E. has the greater range of interests and is the inclusive organization. All of our members should be, as many of them already are, members of the A. I. E. E. also. We must regard ourselves as a part of the great body of electrical engineers, and at the same time as a group of specialists who for the advancement of our individual and collective interests as steel mill engineers must maintain our organization as an independent entity.

With the increasing variety and complexity of electrical interests, the line of cleavage between the so-called operating engineer and the engineer who confines himself to research or design threatens to become even more sharply defined and, while this to a certain extent is inevitable, it is most unfortunate. We must each exert himself to overcome this natural tendency and endeavor to become familiar with others' problems at least to the extent of yielding intelligent appreciation of their efforts.

As operating engineers we cannot escape the fact that we are deeply indebted to those of our profession who spend their time and energy in experimental and analytical investigation of such natural resources and phenomena as have not yet been brought to a state of practical utility. The man who by virtue of natural ability and opportunity gives himself to research and the classification of theories will naturally tend to foregather with those of similar interests. This is equally true of the man who, lacking the opportunity for intensive training in a technical institution, has been forced to accumulate his experience first-hand from direct contact with problems of installation and operation. There are extremes of each of these types who can never speak a common language, but the great majority of us in whatsoever manner our experience may have been gained, will be mutually benefited by closer association and interchange of ideas. We must avoid the danger of "inbreeding" which is just as real in engineering as in agricultural pursuits. Professional jealousy or indifference and its resulting insularity of ideas is more often than otherwise a confession of weakness. On the other hand competition and professional rivalry are most desirable and should be encouraged.

We have heard much in recent months of the need of "Less Government in Business and More Business in Government." We should go further. We need "More Engineering in Government, Both Local and National."

We need the same kind of reasoning and the same type of administrative methods in our civic affairs that we find in force in any of our great engineering works. The trained engineer compelled to look facts squarely in the face, who deals daily with the unchanging characteristics of material substances, and the laws which govern the transformation and dissipation of energy, comes to consider orderliness and the elimination of waste whether of effort or materials, as the greatest of human objectives. His one aim in life is to bring the margin between actual achievement and 100 per cent efficiency to an irreducible minimum.

The engineer is coming into his own at last largely because of a clearer recognition and personal acceptance of the part which his training and experience peculiarly fit him to play in moulding public opinion and directing public affairs.

Engineering has been defined as "the art of utilizing the materials and controlling the forces of nature for the benefit of mankind." This definition falls short of its intended scope fi it does not include among the available "material and forces of nature," the personalities and mental equipment of our fellow men. In these days of industrial and social unrest we need as never before the clear vision and straightforward reasoning of the engineering mind with its power of discrimination between fact and fancy, and its logical deduction therefrom unbiased by sentiment or emotion. As engineers and as citizens we must face and accept the responsibilities which are inseparable from the privileges of education and experience which this country affords. It is up to us as individuals and as an organized body in the interests of society, which includes equally, ourselves, those for whom we work, and those who work under our direction—to exert ourselves to counteract the unsound propaganda put forth by unscrupulous or at best uninformed leaders of organized labor. Unfortunately the danger to our social and industrial life from this source is scarcely greater than from the emotionalism of many of our self-appointed modern reformers who through the media of the lecture platform, pulpit and press are vigorously attacking with sweeping condemnation the whole industrial system. The danger from this source lies not so much in the evils revealed as in the misrepresentation of facts through carlessness or by malicious intent and the erroneous deductions therefrom. The total absence of constructive criticism on the part of these would-be reformers cannot fail to leave in the minds of the average person who rarely takes the troubles to ascertain the facts and form unbiased opinions, an impression of unrest, discontent and hopelessness entirely unjustified by actual conditions.

Anti-Friction Bearings in the Steel Mill

By A. M. MacCUTCHEON.

THE history of the anti-friction bearing is closely identified with the development of the bicycle and the automobile. Elimination of friction has always been a most fascinating study in all branches of engineering. There is no authentic record of the date at which it was found that rolling friction was less than sliding friction, but presume it was at that time when our forefathers found it easier to roll than to drag a body. The use of rollers under a block of stone was known to the ancient Egyptians. Wheels used on chariots marked the first development in changing rolling friction betwen the ground and the weight, to rubbing friction in an axle. Later it was found that if the surface in the hub where the friction took place were properly prepared and lubricated, a great reduction in friction resulted. Bearing development has generally been in the direction of reducing friction and increasing reliability. Crude ball bearings were first considered about 1862 to 1870, the Patent Office files showing several patent applications at about this date. These early ball bearings, however, were not practical and are merely of theoretical interest. The first practical applications came in the early nineties with the use of the cup and cone bearings on bicycles. The tremendous development of this industry furnished the stimulus for a very intensive effort toward the production of a bearing which could be more general in its application. The first type of the annular or ring ball bearing was developed about 1901, based upon investigation made by Professor Strybeck. The annular bearing consists of two entirely independent concentric rings of practically rectangular section and with groove shaped raceways in the outer surface of the inner ring, and the inner surface of the outer ring. In this groove a row of balls is placed and the whole is a self-contained, non-adjusting bearing. It was recognized that theoretically the annular bearing should contain as many balls as the space permitted. The number of balls which may be introduced in any bearing is very intimately connected with the method of assembly, which will be discussed in greater detail under the various types of bearings. One method is to have a slot in the side of the bearing which method permits of the maximum number of balls, but which results in a break in the continuity of the race and usually seems to necessitate the use of a shallower groove.

Another method is embodied in the Conrad patent, in which the introduction of the balls takes place by means of an eccentric displacement of the rings in relation to each other.

With this method the number of balls which may be introduced is limited, the raceway, however, is continuous and very deep grooves may be used. At

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Abstract of Iron and Steel Electrical Engineers Convention paper.

about this time a large number of ball and roller bearings were designed and built, some of which proved to be very satisfactory, and some quite the contrary. Little was known as to the proper selection of the size of balls, and many misapplications were made. Some of the engineers working on the anti-friction bearing problems felt rollers would be more desirable than balls for use in a bearing, claiming that with a roller line contact is secured as opposed to point contact in a ball bearing.

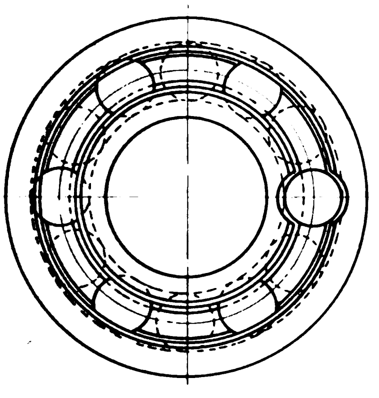

Fig. 1—Assembly of Balls.

This claim, however, is not conceded by the manufacturer of ball bearings. One particular type of bearing which has been very largely used was developed with a roll not solid but made up of a spiral. Considerable difficulty was experienced with misalignment, and the consequent stresses not anticipated in the design. In 1906, a native of Sweden invented a two row annular bearing with a self-aligning feature, which it was claimed eliminated the sensitiveness to misalignment. Another claim for the double row bearing is the increased number of balls which may be introduced in such a bearing. In 1905 the first commercial application of annular ball bearings was made in America, although these bearings had been previously used in some of the foreign countries.

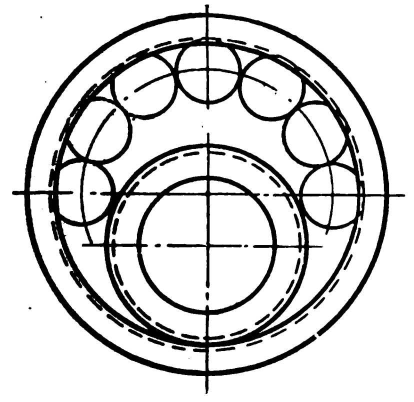

Fig. 2—Assembly of Balls.

The application was on a marble polishing machine for the Empire City Iron Works in Long Island, and the application proved quite satisfactory. At about the same time the first application of ball bearings was made on electric motors. It is at least interesting to note that the two electrical manufacturing companies who were the pioneers in the use of ball bearings for motors are still using such bearings, and consider them entirely safisfactory. In 1905, ball bearings were being favorably considered by the automobile industry, and during that year they were applied to the transmission of a 50 Hp Thomas Flyer. In 1906, an Apperson built for the Vanderbilt Cup Race had its transmission so equipped. In 1910, one of the machine tool companies exhibited at Atlantic City and elswhere a vertical spindle drill press mounted on ball bearings, which drove an inch and a half drill through 31 inches of cast iron per minute, and a three and a half inch drill through 11½ inches of metal per minute. This of course meant a very heavy end thrust on the bearings. Also in 1910 ball bearings were used to take the thrust on belted vertical milling machines. It is interesting to know that ball bearings have been used on power punch presses where there is undoubtedly a very heavy shock condition. The claim is made that on such a press the use of anti-friction bearings decreased the idle stroke power 54 per cent and the working stroke power 20 per cent, and that the power saving for the complete cycle was 40 per cent.

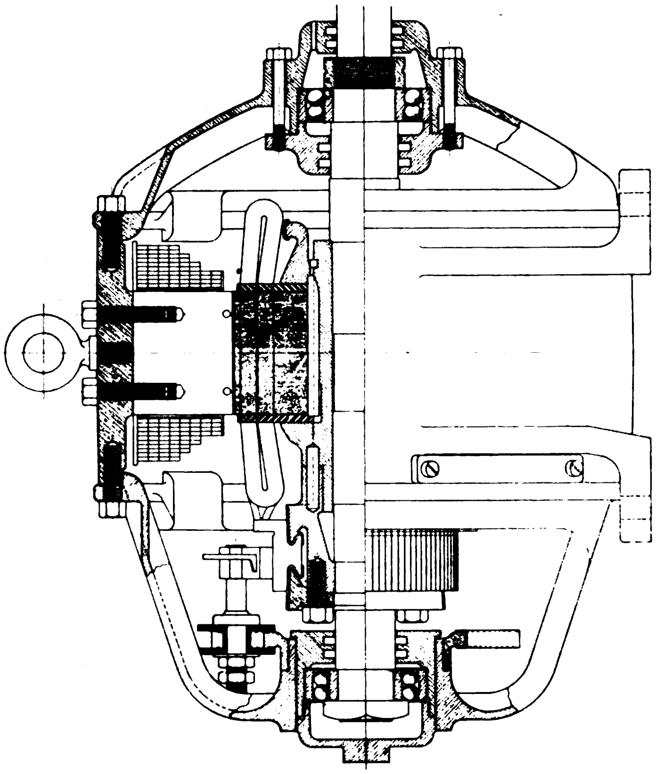

Fig. 3—Ball Bearing Mounting.

1910 marked another interesting application of anti-friction bearings to a cold saw which ran at 4100 rpm. The use of plain bearings had required renewal of the bearing about once in three weeks with the consequent shutting down of the machine. Twenty hp was required to drive the saw when equipped with oil type bearings, and water cooling was employed. After the change in the bearings a 7½ hp motor was substituted for the 20 hp, and there is no evidence that further bearing trouble occurred on the machine. Since that time anti-friction bearings have become extensively used in the automobile, aeroplanes, lathes, grinders, planers, drill presses, textile machinery, woodworking machinery, pulp and paper machinery, grain milling machinery, farm tractors, pumps, printing presses, portable tools, ventilating fans, shaft hangers, electric motors and on many other machines. The early days of anti-friction bearing application saw many failures, possibly due to lack of knowledge and the consequent misapplication. It is undoubtedly true that the anti-friction bearings being manufactured today are vastly superior to those manufactured 10 or 15 years ago.

In no other line of manufacture has there been a greater attempt at standardization and many of the bearings of different manufacturers are absolutely interchangeable. Careful consideration of the history of the anti-friction bearing industry would seem to indicate that this type of bearing certainly merits a careful study by any industry. Requests for information were therefore forwarded to the various ball bearing manufacturers, the railway electrical engineers, machine tool builders, the motor manufacturers and such of the steel mills as were known to have done some experimental work relative to the use of anti-friction bearings. Their experience is discussed more fully later in the paper.

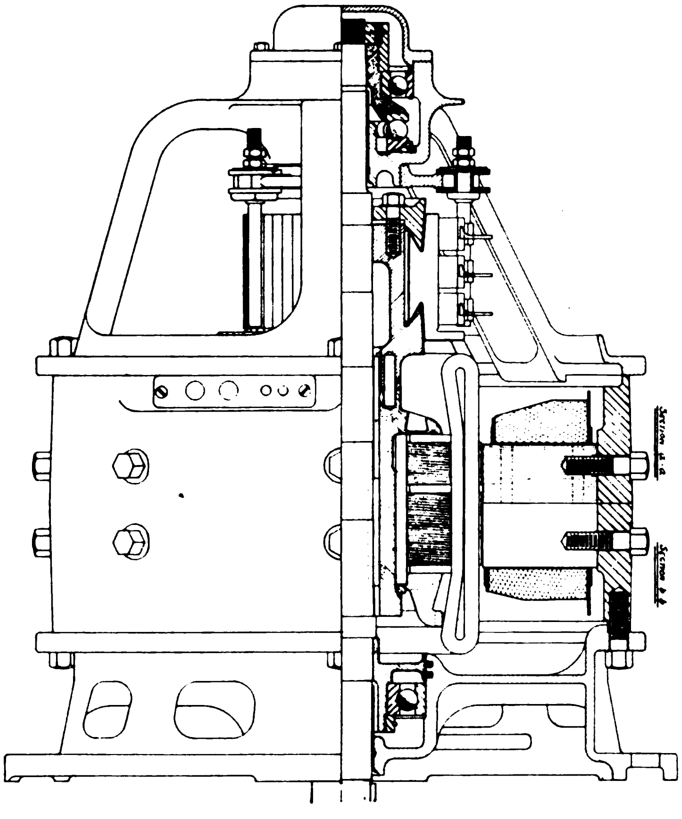

Fig. 4—Vertical Ball Bearing Mounting.

It is interesting to note that the catalog published by one of the anti-friction manufacturers lists a bearing ½-inch outside diameter and which weighs scarcely more than a few ounces, while the largest is over 19 inches in outside diameter and weighs approximately 300 pounds. Special large radial bearings have been made by this company, having an outside diameter of 32¼ inches and a bore of 15¾ inches. This bearing is fitted with 34 balls 4¼ inches in diameter and has a total weight of 1,000 pounds. The bearing will carry a weight of 80 tons at 100 rpm.

Today many types of anti-friction bearings are being manufactured, to some of which reference has already been made. A classification with examples of each type will undoubtedly be of interest. No type or manufacturer has intentionally been omitted, but the information is not complete.

1. BALL BEARINGS

(a) Annular Type with Deep Grooves Ball Assembled by Eccentric Displacement of the Races.

The Hess Bright Ball Bearing Company.
The Fafnir Ball Bearing Company.

(b) Annular Type with Balls Assembled through Filling Slots Permitting of a Large Number of Balls.

Ball bearings manufactured by the Standard Roller Bearing Company.

(c) Annular Type with Balls Assembled by Expansion of the Outer Race under Heat, permitting of a large number of balls.

The Gurney Ball Bearing Company.

(d) Annular Type with a Double Row of Balls Permitting of a Larger Number of Balls.

The New Departure Ball Bearing Company.

(e) Annular Type with a Double Row of Balls and Self-Aligning Features.

S K F Ball Bearing Company.

2. ROLLER BEARINGS

(a) Self-contained with the Inner and Outer Races forming a cage for the Rolls. Rolls assembled through filling grove.

The Rollway Roller Bearing Company.

(b) Semi-flexible Spiral Roll assembled between End Cages and with the Outer and Inner Race slipped over and within the Rolls, permitting of easy disassembly, but not capable of taking end thrust.

The Hyatt Roller Bearing Company.

(c) Tapered Rolls assembled between End Cages and with Tapered Races, permitting of easy disassembly, taking end thrust, and making possible adjustment for wear.

The Timken Roller Bearing Company.

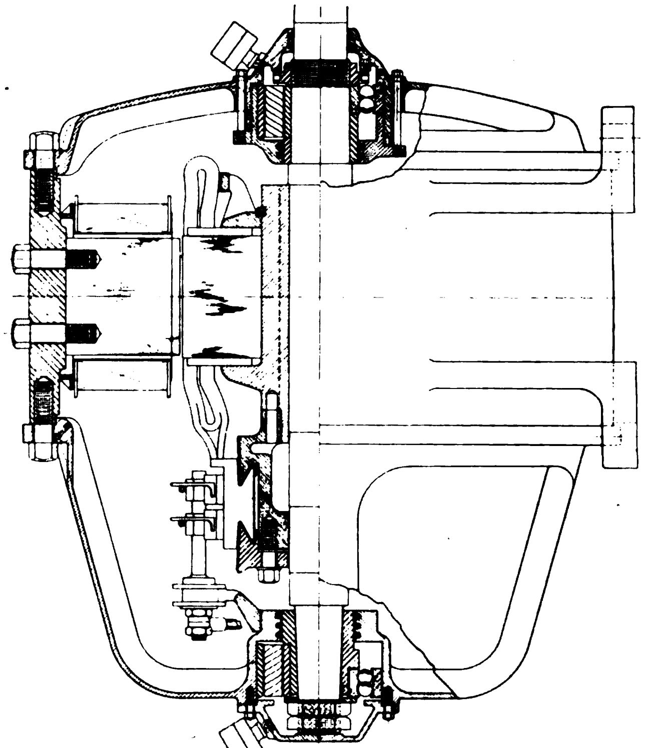

Fig. 5—Ball and Roller Bearing Mounting.

Practically all types of ball and roller bearings are assembled with end cages which maintain the proper relation in position of the ball and rolls. The proper design of these end cages is as necessary as the proper design of the rest of the bearing.

Manufacture.

The manufacture of anti-friction bearing is a highly specialized industry requiring special machinery, special materials and special operation. All bearings must be subjected to exceedingly rigid inspection and test. The three most important properties which a finished anti-friction bearing should possess are (1) High fatigue limit and strength. (2) High resistance to shock. (3) Highest possible resistance to wear. Each bar of steel used in the manufacture of balls or rolls and races is tested. The steel must possess in the highest degree the qualities of hardness, toughness, durability after hardening and resistance to shock. The best grade of balls are made of chrome alloy steel and carefully heat treated. They are hardened clear through which makes the steel tough and less liable to crack under excessive load. The balls must be as spherical as it is possible to make them. The best grade balls are ground to size within one ten thousandth of an inch. This accuracy is necessary to secure uniformity in the size of the balls and the consequent even distribution of the load. The manufacture of a ball involves eleven main operations as follows:

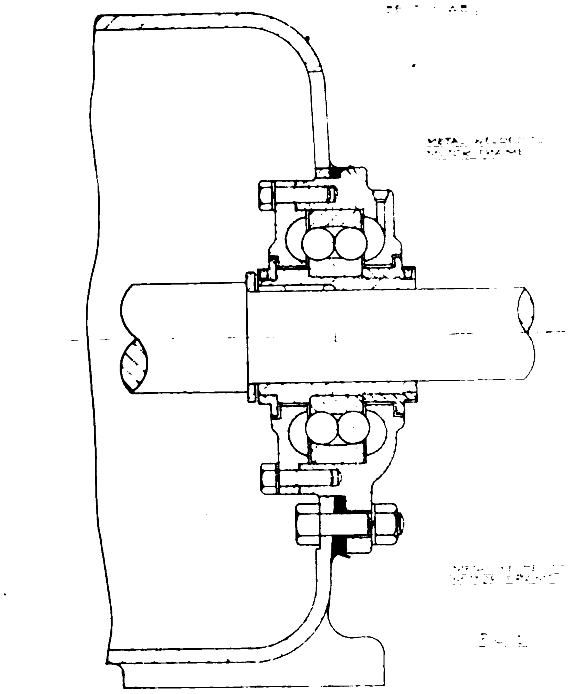

Fig. 6—Ball Bearing Mounting, Mill Type Motor.

1. Inspection and testing of steel stock.
2. Forging or pressing in dies into rough spheres.
3. Annealing to eliminate internal strain.
4. Rough grinding.
5. Second heat treatment. The balls are hardened and then drawn to toughen the steel.
6. Second rough grinding to a fairly smooth surface and more accurate spherically but still considerably oversize.
7. Precision grinding with fine grade wheels and heavy oil holding an abrasive in suspension.
8. Final grinding in Hoffman machine, in which the balls are ground to within a small fraction of the finished size.
9. Polishing balls in a tumbling barrel.
10. Burnishing the balls by which the surface is polished to a mirror finish.
11. Final inspection and test for hardness, sphericity and size.

The balls are gaged with special machines calibrated with special care and by the use of an instrument with which it is possible to determine the size of the steel ball to an accuracy of within .00005. The same care is exercised in the manufacture of the races. One of the bearing manufacturers advises that it is necessary to manufacture their own steel because of the exacting specifications. The steel tubes of which the races are manufactured are formed by forcing through the entire length of a steel bar a pointed steel tool, which results in a tube free of welds, laps or seams and which has a uniform strength and texture on its entire circumference. The tubes are finally cold drawn to a size within a very close limit. This brief summary of manufacture has been given in the belief that a general understanding of the care exercised in the manufacture of anti-friction bearings will result in a more intelligent consideration of their use.

Selection of Anti-Friction Bearings.

Experience has demonstrated that many failures have resulted from the improper selection of the size of bearing to be used, for a particular application. If anti-friction bearings are applied to motors, close cooperation is essential between the motor manufacturer and the ball bearing manufacturer. About four years ago the writer of this paper discussed with an electrical engineer of a well-known eastern railroad the success which they had experienced with ball bearings on car lighting generators. The advice of this engineer was to select a bearing two sizes larger than indicated by a consideration of the load which the bearing was expected to carry, and the load which the bearing was guaranteed to carry. He attributed the entire absence of trouble on car lighting outfits to the following of this plan. In justice to the manufacturer of the anti-friction bearing, it should be stated that since that time

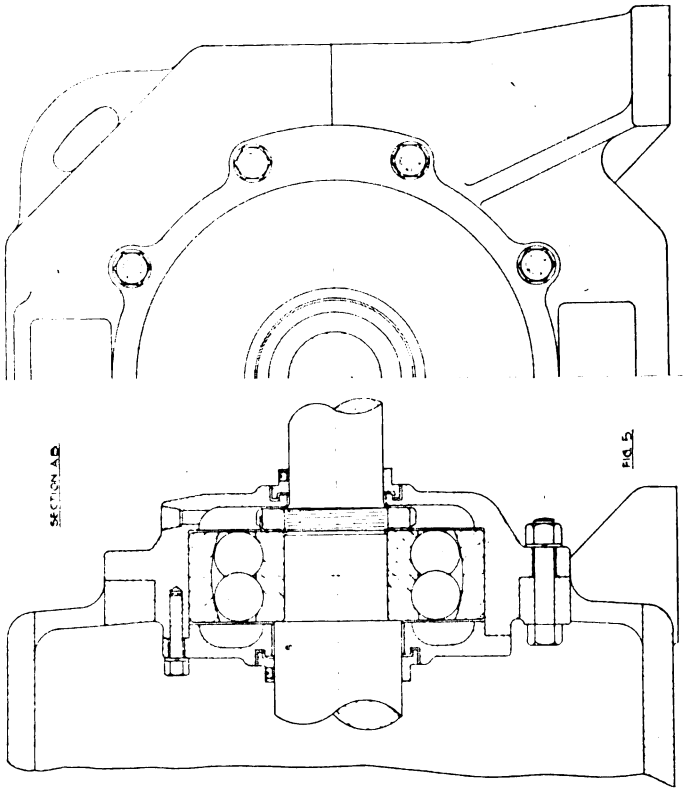

Fig. 7—Ball Bearing Mounting, Mill Type Motor.

a very exhaustive study has been made of the requirements of anti-friction bearings applied to motors so that they are in a far better position today than they were at that time to specify the safe working load for the bearing. From many sources information has been received that if the bearing is selected large enough and properly applied, no failure will ever result. This undoubtedly is an extreme view but is interesting as evidence of the confidence which some users of anti-friction bearings have in this type.

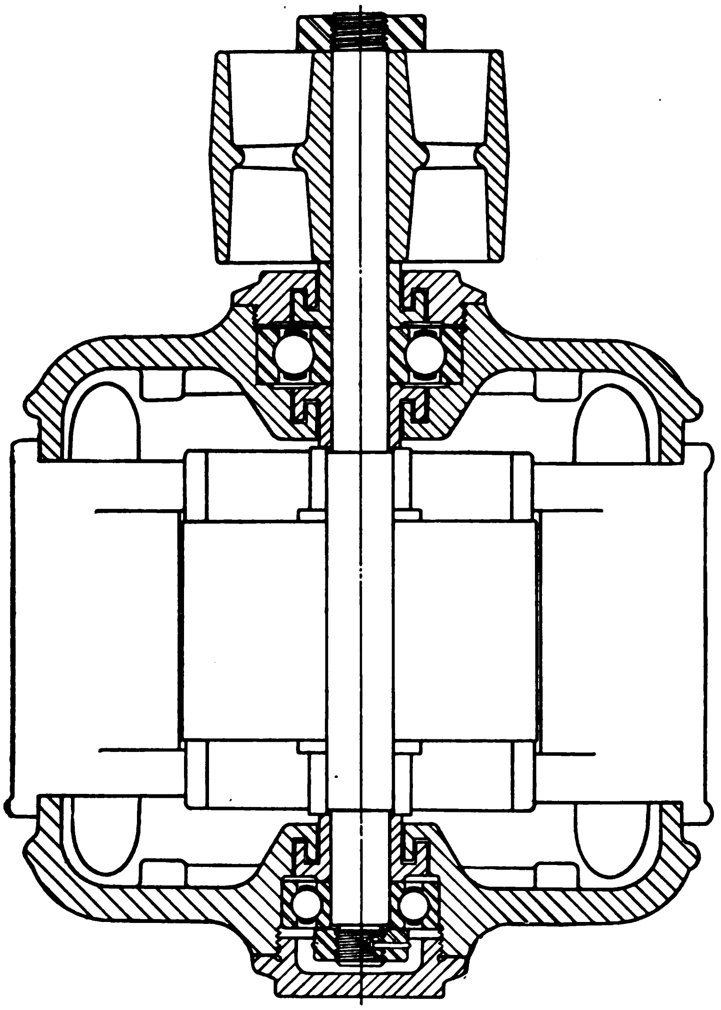

Fig. 8—Ball Bearing Mounting, Labyrinth Grooves.

Mounting of Anti-Friction Bearings.

In succesfully designing a mounting of an anti-friction bearing motor, the following points must be kept in mind:

a. Ease of assembly. It should be possible to draw the bearing off the shaft without transmitting pressure from the outer race to the inner race through the ball. It should be possible to remove the armature without the removal of the bearing from the shaft.

b. The bearing should be protected against the entrance of dirt or grit. If such foreign substances are present within the bearing, the life of the bearing will be very short.

c. The lubricant must be retained within the bearing housing.

d. The bearing must be the proper fit on the shaft and within the housing.

e. The inner race of bearing must be locked in place against a suitable shoulder by a suitable locking nut.

Illustration 3 represents a typical mounting on a general service direct current motor. Attention is drawn to the mounting at the commutator end where the bearing is entirely enclosed in a cartridge which is removed from the motor with the armature. It is believed that such enclosure is the most satisfactory form of mounting but is somewhat more expensive. It is evident that the armature may be entirely removed from the motor without disturbing the fit of the ball bearing on the shaft. A suitable mounting is always difficult at the commutator end of a direct current motor of the general service type since the outer dimensions of the bearing housing are limited by the position of the rocker.

Figure 4 is a typical mounting of a vertical general service motor in which the weight of an armature is carried by a thrust ball bearing at the top.

Figure 5 is a composite mounting showing the application of a ball or roller bearing to the same general service motor.

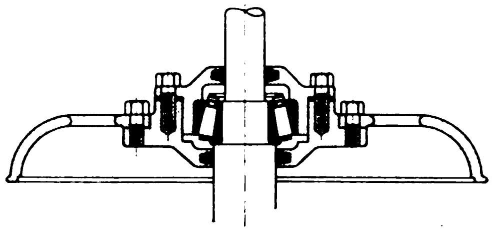

Fig. 9—Roller Bearing Mounting, Enclosed.

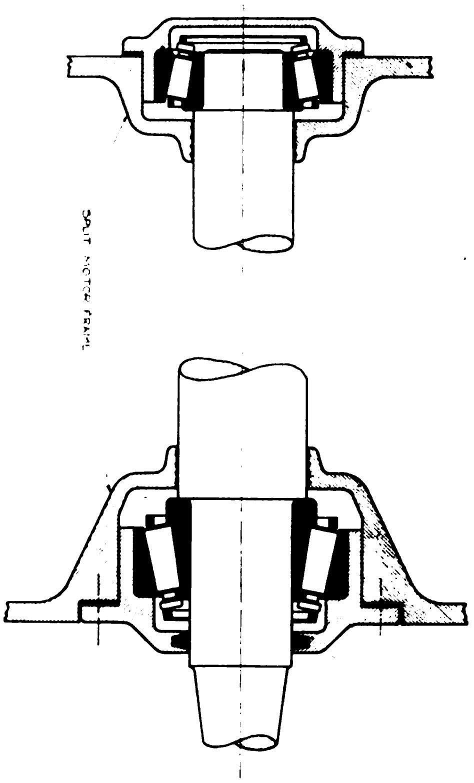

Fig. 10—Roller Bearing Mounting.

Figure 6 is an application of a ball bearing to a mill type motor. The bearing is completely enclosed in a cartridge which is removed from the motor with the armature, effectively excluding foreign substances. This application was laid out in connection with changing over oil type motors to anti-friction type. The ball bearing is mounted on a sleeve which is driven by a Woodruff key. The sleeve has the advantage of a long bearing on the shaft and may be required in very heavy service. In general it is not felt that it is necessary. Certainly not on general service motors.

Figure 7 represents the mounting of a ball bearing in a steel mill motor with the bearing carried directly on the shaft and without the cartridge enclosing the bearing. Unusually complete protection is provided against the escape of grease by what may be described as the "labyrinth" type of groove. Nearly all types of anti-friction bearings will take a very considerable end thrust; from 30 to 40 per cent of the radial capacity of the bearing up to 100 per cent or over. It is, therefore, not necessary to provide any other device to take the end thrust ordinarily found in motors.

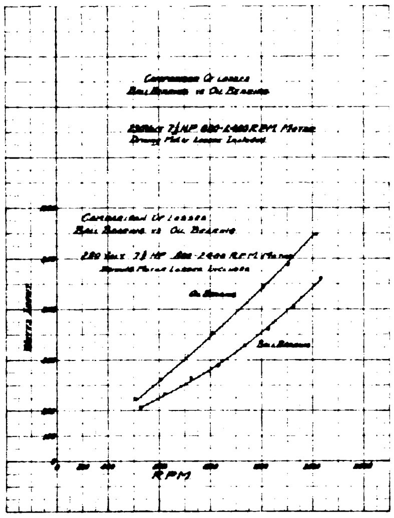

Fig. 11—Test Comparison, Ball and Oil Bearing Motor.

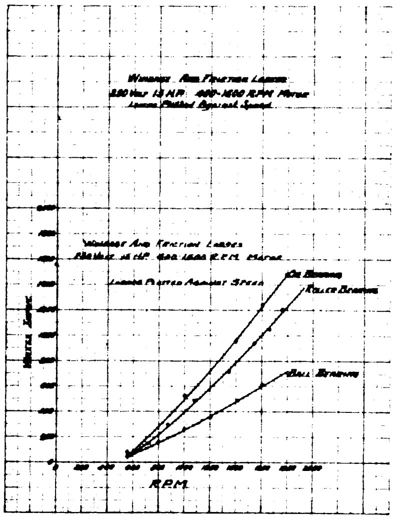

Fig. 12—Test Comparison, Ball, Roller and Oil Bearing Motor.

Figure 8 shows an application to a general service motor with the "labyrinth" type of grease groove, but this mounting does not permit of the removal of the armature without the removal of the bearings from the shaft, and therefore is not to be recommended, certainly not in a steel plant.

Figure 9 shows the application of a tapered roller bearing with the bearing completely enclosed in a cartridge. Disassembly is accomplished by removing the outer cap screws and rotating the cartridge so that the extended bosses will clear the extended bosses on the bracket. Wear on such a bearing may be compensated for by removing shims between the outer and inner enclosing caps.

Figure 10 represents the installation of a tapered roller bearing in a split frame motor. The armature may then be removed by lifting the top half of the frame. The shims for adjustment after wear are again evident.

Consideration should be given to allowing a fair sized space for lubricant and to the introduction of such lubricant through a tapped hole closed with a pipe plug, a grease cup or some other suitable means. All ball bearing manufacturers seem to be in accord that the inner race should be mounted on the shaft with a light drive fit, from .006 to•.002 force, depending upon the size of the shaft. The entire paper might be devoted to a discussion of the proper fit and tolerances on ball bearings and shafts. The outer race should be a sucking fit in its housing permitting a slight creepage of the outer race if such a tendency is present. The end play should be taken on one bearing and the one carrying the heavier load is preferable. Either grease or oil may be used for lubrication; for speeds up to 2,000 rpm on 5 to 20 hp motors, grease is recommended because of the advantage in eliminating any possibility of oil getting into the motor. At very high peripheral speed, oil is found to be preferable.

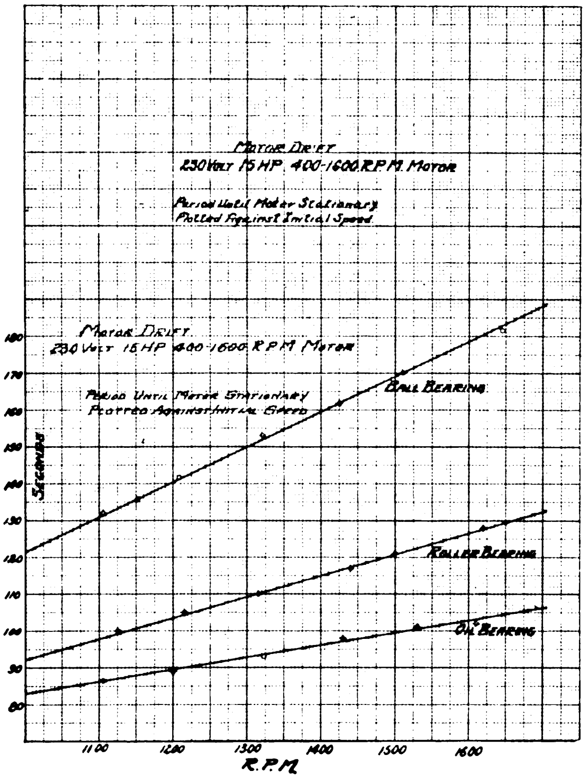

Fig. 13—Test Comparison, Time of Drift.

Care of Ball Bearings.

From the data available, it is evident that great care must be exercised to protect the ball bearing before installation in the motor and during the process of assembly against the entrance of any grit or foreign substance, as the presence of such substance will most certainly result in wear and the eventual failure of the bearing. If the armature is removed from the frame with the bearing not enclosed in a cartridge, the bearing should be carefully wrapped while the armature is out of the motor. To offset this, it is claimed that very little attention need be given to the lubrication of the bearing while the motor is in operation. There are cases on record where anti-friction bearings have operated over a period of three to four years without being greased. This is of course not recommended. Speed and heat conditions are the governing factors. Wherever possible grease should be applied at intervals of about six months. Probably the best practice would be for the operator to make monthly inspections at the time of the installation in order to judge how long the lubricant will remain serviceable under the conditions existing in that particular plant, and then establish a period for applying grease. In no case should the housing be packed full of grease as it will cause severe heating in operation. It is the practice of the ball bearing manufacturer to slush their bearings with a coating to avoid rust. Before installation, the bearings should be cleaned in gasoline to remove this slush, as it is not a good lubricant and will cause heating under certain conditions.

Arguments For and Against the Use of Anti-Friction Bearings.

The history, manufacture and application or mounting of anti-friction bearings may be of interest to the electrical engineer, but the real question which he wishes to consider is what are the advantages of such a type of bearing, and what are the disadvantages.

Advantages.

The advantages are presented in summary form compiled from the information received from the bearing manufacturers and the users of this type of bearing.

1. Absence of oil. By various steel mill electrical engineers it has been estimated that the presence of oil is responsible for from 60 to 90 per cent of their motor troubles, causing injury to the insulation, shorting of commutator bars, gumming of commutator, collecting dust and a general unsightly condition. The lubricant is more easily retained in a ball or roller bearing than in a sleeve bearing.
2. Reduction in maintenance cost. Much less frequent attention need be given to the lubrication of a ball or roller bearing. The weight of the evidence received from the users of anti-friction bearing motors is to the effect that failure of bearings is very much less frequent than on oil-ring bearing motors.
3. Reduced wear of the bearing, resulting in much less frequent renewal of the bearings due to the lowering of the rotor, and the consequent decreased air gap at the bottom. This consideration is of particular importance on induction motors with their necessarily small air gaps.
4. Increased efficiency. A record was presented of a test on a 3-hp, 1,800-rpm induction motor. Three motors were used, one equipped with ring oiler bearings, another with waste packed bearings and the third with ball bearings. The test showed the following efficiency:

Ring oiling bearing.........	81½%
Waste packed	80¼%
Ball bearing	84¾%

5. A considerably decreased torque is necessary at starting. In the case of an oil ring bearing, sufficient torque must be applied to break the contact of the shaft on the bearing metal before the oil film is established.
6. Anti-friction bearings make possible a considerable reduction in the overall length and in the weight of the end housing. Babbitted bearings are quite usually designed with the bearing length two and one-half or three times the diameter of the shaft, whereas the length of the ball bearings is usually not over one-third of the shaft diameter. A ball bearing is usually not over one third of the shaft diameter. A ball bearing manufacturer has advised that a tabulation of standard motor sizes proves that the overall length can be reduced on an average of 15 to 20 per cent by the use of ball bearings.
7. The information received from the railroads, the government and the steel mills which have experimented with anti-friction bearings, indicate that these bearings, have been successful, and this experience should certainly be classed as a strong argument for the use of such bearings.

Disadvantages.

1. Cost. The first cost of the motor will be greater and two lines of motors will have to be manufactured as long as the users of motors are not unanimous in their opinion. If the user changes to the anti-friction type of bearings, it will be necessary for him to carry two lines of spares until all of the oil ring bearing motors have worn out or been replaced.
2. Difficulty in making replacements. It does not seem that it will ever be possible to replace a ball bearing as easily as an oil ring bearing. To secure proper operation, it is necessary that the inner race be tight on the shaft, which prevents its easy removal. For steel mill operation, it may be necessary to carry complete armatures with bearings assembled. This would certainly not be justified unless the reduction in the number of bearing troubles more than compensated for this extra expense.
3. The care which is necessary in successfully mounting anti-friction bearings and assembling the armature in the frame. The oil ring type of bearing does not require the careful assembly needful with an anti-friction bearing.
4. It is essential to very carefully protect anti-friction bearings in handling and installation. This is readily recognized as a disadvantage in the steel plants.
5. The workman in the steel mill is unfamiliar with the mounting of anti-friction bearings, and the assembly of such motors. This must be charged up as a disadvantage until such time as the average worker becomes sufficiently familiar with this type of motor to be able to disassemble it without any difficulty or detailed instruction.
6. In cases of armature grounding, current may pass through the balls or rollers and the races, causing pitting; in extreme cases actually fusing the race to the balls or rolls.
7. Under emergency conditions where a spare bearing is not available, the oil ring type of bearing may be babbited or cast by any reasonably good workman. This is not possible with the anti-friction type.
8. The strongest argument against the use of the anti-friction bearings, or any other device is the fact that it has not been thoroughly proven under actual operating conditions. Whether or not the anti-friction bearing will stand up as well as oil ring bearing under shock and unusual load conditions has not yet been conclusively demonstrated. Until the case for the anti-friction bearings has been firmly established, they must be recognized as being on trial.

Illustrations 11, 12 and 13 represent the results of tests conducted under the direction of the writer.

In the first case, illustrated by Fig. 11, two motors normally rated at 7½ hp, 850 rpm, with 9¼-inch diameter armature, were at different times belt driven by the same motor. One of the machines under test was equipped with oil ring bearings and the other with ball bearings. In all other ways the two test machines were identical. The watt input represents not only the friction and windage losses of the machine under test, but also the losses of the driving motor. However, since the driving motor was the same in each case, the difference between the losses will represent the saving of the ball bearing over the oil ring bearing.

The second case, illustrated in Fig. 12, represents a somewhat similar test conducted on three motors normally rated, 30 hp at 850 rpm. Motors were identical excepting the bearings; one was equipped with oil ring bearings, a second with Hyatt roller bearings and the third with Hess Bright ball bearings. In this test the losses of the driving motor were deducted from the watt input, and the only inaccuracy is that the losses shown include the belt loss. It is interesting to note that at slow speeds, the reduction in loss with the use of ball bearings is not nearly so apparent as at high speeds. It is further interesting to note that the loss with roller bearings falls between the loss with oil bearings and with ball bearings, and more closely follows the line of the oil bearing loss at the high speed.

The third case, illustrated by Fig. 13, represents the test on the same three motors with the number of seconds that the armature would rotate after shutting off the power, plotted against the speed. The results in this test quite closely checked in quantitative value the tests represented in Illustration 12. Sufficient tests have not been made to present conclusive evidence, and a great many more should be conducted, but as far as the investigation has proceeded it would appear certain that motors equipped with anti-friction bearings result in a saving of power.

While the railroads have had a very successful experience with car lighting generators, so equipped, their experience with head light generators has not been the same. In the early history of anti-friction bearings applied to motors appear many cases of complete failure, and while this may have been due to misapplication or to improper mounting, these examples must be lived down, before the anti-friction bearing receives a clean bill-of-health. It is somewhat doubtful whether this type of bearing is satisfactory with heavy armatures having considerable distance between the bearing centers and operating at high speed. There have been quite a large number of failures under such conditions, resulting in excessive vibration and in the peening under the inner race. This trouble has been particularly evident on two bearing arc welding motor generator sets. Additional detailed evidence was presented in this paper under the head of "Experiences of Users and Manufacturers."

Waste Heat Utilization for Steam Generation

By G. R. McDERMOTT.

THE purpose in presenting this paper is to bring to the attention of the members of the Association what has been accomplished in the utilization of waste gases for the purpose of steam generation and to point out sources of waste heat which may be available.

The term waste heat is inclusive of the total heat left in gases of combustion when they have served their primary purpose of roasting, reducing, oxidizing or heating in industrial or metallurgical furnaces or kilns. Furnaces employing regeneration or recuperation commonly have left in the gases of combustion, leaving the furnace from 35 to 55 per cent of the total heat available in the fuel fired. Non-regenerative furnaces may have as high as 80 per cent of heat in the fuel escaping in waste gases of combustion. Kilns, oil stills, glass tanks, water gas sets, etc., all present, on account of the amounts and temperatures of escaping gases of combustion, amounts of waste heat that are not only recoverable, but that give returns which will net from 25 to 75 per cent in one year on the installation cost of the quipment.

The past three years have seen marked increases in the price of coal and we should utilize the waste heat available, not only as an individual plant economy, but as a conservation of the national resources.

The very first studies that were made and the first successful application of waste heat boilers for furnaces with regenerators was effected at the Illinois Steel Company, South Chicago. The first installation was operated in 1910 and upon the very important discoveries then made have been based the rapid developments and applications of the modern waste heat boilers.

Before taking up the different sources of waste heat, it, no doubt, will be of interest to consider the heat and absorption phenomena obtained in a direct-fired boiler and that of a modern waste-heat boiler.

Many experiments have shown that the heat absorbed by radiation is proportional to the fourth power of the absolute temperature difference between the radiating surfaces. Considering a stoker fired boiler with combustion temperature at 2700 degrees F., and a waste-heat boiler at 1300 degrees F. initial temperature, the absorption by radiation would be as

$$\frac{T^4 \text{ (coal)}}{T^4 \text{ (waste heat)}} :: \frac{2700^4}{1300^4} :: \frac{10.5}{1}$$

The absorption by radiation in the case of the direct-fired boiler will be ten times as great as in the case of the waste-heat boiler.

Usually about 65 per cent of the total evaporation is by radiation and 35 per cent by convection, as, for example, in a 600 hp boiler, 7,025,000 Btu. are absorbed by convection and 13,050,000 Btu. by radiation. In the waste-heat boiler only 1,300,000 Btu. can be absorbed by radiation, leaving 18,700,000 Btu. to be absorbed by convection. Therefore, the rate of heat transfer by convection must be, for waste heat boilers, 2.75 times greater per square foot of heating surface. This difference is further aggravated by the fact that

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Abstract of paper read at Association of Iron and Steel Electrical Engineers Convention, Chicago, September, 1921.

in the modern waste-heat boiler the amount of heating surface exposed to the radiant that of the furnace is very much less in proportion to the total heating surface as in the case of the direct-fired boiler.

Obviously for a given gas weight, starting in with an initial temperature of 2700 degrees F. and 1300 degrees F., respectively, passing through or past an identical heating surface of a boiler, and having identical exit temperatures, the net amount of heat absorbed by convection by the heating surface must be much greater for the waste heat boiler with initial temperature of 1300 degrees F. For each square foot of heating surface of the boiler, therefore, the heat transferred by convection must jump to a figure hitherto considered impracticable. This point of view is not always appreciated. It is not infrequently felt that since a low temperature waste heat boiler gives but 70 to 80 per cent of builders' rating that the heat transfer rate is low. Actually it is very high.

An increase in heat transfer rate is accomplished by an increase in velocity. Consideration of the formulae governing this phenomena will develop the reasons.

The rate of heat transfer for either fire-tube or water-tube boilers may be expressed in the form

$$R = \frac{H}{T - t} = a + b\,\frac{W}{A}$$

where

R = heat transfer rate in Btu. per hour per square foot of heating surface per degree F. difference in temperature.
H = Btu. transferred per hour per square foot.
a and b = Constants.
$\frac{W}{A}$ = Mass velocity expressed as pounds of gas per hour per square foot of area of gas passage.

In general the constant "a"

1. is greater for water tubes than for fire tubes of same size.
2. is greater as diameter of tube decreases.
3. is greater as space between water tubes decreases.

Similarly, constant "b," which is the inclination of the line representing "R" when plotted against mass velocity.

$$\frac{\text{“W”}}{\text{“A”}}$$

1. Is greater for water tubes than for fire tubes.
2. Is greater as diameter of tube decreases.
3. Is greater as temperature difference between steam and water increases.

For the constants "a" and "b," values may be assigned that are sufficiently accurate for all ordinary engineering applications and are derived from reliable tests and investigations conducted by boiler companies and independent observers.

The following formulae are given as they illustrate the relative heat absorbing characteristics of the two types of boilers, the data being taken mainly from tests made by the Babcock & Wilcox Company on both fire-tube and water-tube boilers; by Messrs. Kreisinger and Ray, on small fire-tubes, and confirmed by tests on two-pass waste heat boilers later described in this paper.

Outside Diameter of Tubes—Inches	Fire Tubes	Water Tubes
1	$R = 3.5 \text{ plus } .0013 \frac{W}{A}$	
2	$= 2.0 \text{ plus } .0008 \frac{W}{A}$	
3	$= 1.5 \text{ plus } .00065 \frac{W}{A}$	
4	$= 1.1 \text{ plus } .0005 \frac{W}{A}$	$R = 2.0 \text{ plus } .0014 \frac{W}{A}$

These values apply to 400 degrees F. mean temperature difference corresponding approximately to waste-heat boiler conditions.

As stated before, the absorption of heat from waste gases covered in this paper must be done largely by convection; that is, the molecules of the flowing gases come in contact with the heating surface of the boiler and impart their heat to it. The rate at which the heat is imparted to a unit surface depends, therefore, on the number of gas molecules coming in contact with it. By referring to the above equations of "R" for different tube diameters, it will be noted that "R" increases with a reduction in the value of "A," or, in other words, with an increase in the mass velocity. This is explained by the fact that the faster the gas moves, the greater the number of molecules or particles of gas that pass each unit of heating surface in a unit of time, and, consequently, the greater the number of hot molecules that will hit or penetrate into the adhering gas film and replace cold molecules of gas. Thus, the dislodging effect of these moving molecules on the molecules of the adhering film is proportional to the velocity of the mass of the gas moving over the heating surface. This absorption phenomena manifests itself to a greater degree when the gases are at or above their "critcal velocity." The term "critical velocity" is that velocity at which the stream lines of flow cease rather suddenly to be parallel, and at which violent eddying begins. This may be illustrated by a thread of colored liquid introduced into the center of a stream of water flowing through a tube. Below a certain velocity the thread of color will remain in the center and quite sharply defined for the entire length of the glass tube; however, with an increase in the velocity the color will disappear or become diffused, indicating that the "critical velocity" has been reached. The violent eddying, due to the gas being at or greater than its critical velocity, will cause a greater number of the gas molecules to hit the tube wall and thereby release their heat. Obviously, the smaller the diameter of fire tube, the closer the gas molecules are to the surface, the sooner they will reach it and the greater the number of contacts each will make in a unit of time. This accounts for the increase in the value of "R" with reduction of flue diameter as given above.

Although the rate of heat transfer at a given mass velocity and the diameter is greater for a water-tube boiler, yet the friction loss of the fire-tube boiler is much less. For example, the average of tests on nine (9) waste-heat boiler installations, using cross baffled water-tube boilers having four-inch tubes shows:

Mass Velocity $\frac{(W)}{(A)}$	Rate of Heat Tranmission (R)	Draft Loss
2,400	5.42	2.07 in.

If a fire-tube boiler, as described later, using three-inch tubes, were used, the conditions would be:

7,630	6.45	2.07 in.

To illustrate this point still further, figures are here presented showing that a fire-tube boiler may be designed that will have less than one-half the heating surface of a horizontal cross-baffled water-tube boiler, and still give the same performance under the same operating conditions. As a basis for comparison, an average size of standard type of water-tube boiler and operating conditions are taken from actual practice.

Published results of tests on seven (7) waste-heat boilers, all of similar horizontal water-tube type with four-inch tubes and cross baffling, show the following averages:

Rate of heat transfer, Btu	5.32
Draft loss—ins. water	1.45
Heating surface—sq. ft	5,030
Weight of gas—lbs. per hr	68,330
Initial temperature—deg. F	1,330
Stack temperature—deg. F	470
Boiler hp.	400

These figures indicate in a general way what may be expected from specially adapted types of water-tube boilers as ordinarily installed and operated. The mass velocity corresponding to the above average heat transfer rate, as computed by formula

$$\text{“}R = 2 \text{ plus } .0014 \frac{W}{A}\text{”}$$

is 2,370 pounds per hour per square foot of passage area.

For the sake of comparison, let us consider some fire-tube boilers so proportioned that the same amount of gas will cause the same loss of draft, viz.: 1.45 inches. Tube sizes are assumed as 1, 2 and 3-inch diameter, as this selection illustrates the super advantages of using small tubes. Three cases are worked out as follows:

Type of Boiler	Horizontal Water Tube	Double Pass Fire Tube	Single Pass —Fire Tube—	
Size of tubes, outside dia.	4 in.	3 in.	2 in.	1 in.
Number of tubes	....	282	525	1,830
Length of tubes—ft.	....	28	14	5
Heating surface—sq. ft.	5,030	5,700	3,400	1,960
Weight of waste gas—lbs. per hr.	68,000	68,000	68,000	68,000
Mass velocity—lbs. per sq. ft.	2,370	5,900	8,000	8,500
Rate of heat transfer—Btu.	5.32	5.34	8.4	14.6
Draft loss—ins. water	1.45	1.45	1.45	1.45
Initial tempt.—deg. F	1,330	1,330	1,330	1,330
Stack tempt.—deg. F	470	470	470	470
Boiler hp.	400	400	400	400

Inasmuch as the rate of heat transfer at high mass velocity varies almost in proportion to the mass velocity, it is obvious that the number of tubes may be decreased without materially affecting the evaporation. This greatly reduces the first cost and the only disadvantage—if, indeed, it be a serious one at all—is the increase in friction loss. For example, the evaporation obtained in the boiler with 1,880 one-inch tubes, five feet long, may be equally well obtained with only one-half the number of tubes by merely increasing the length to 5.25 feet, as

Size of tubes	1 inch O. D.
Length of tubes	5.25 feet
Number of tubes	915
Heating surface	1,130 sq. ft.
Weight of gases	17,000 lbs. per sq. ft.
Mass velocity	68,000 lbs. per hr.
Rate of heat transfer	25.5 Btu.
Draft loss	6.15 inches
Initial gas temperature	1,330 deg. F.
Stack temperature	470 deg. F.
Boiler hp.	400

The greater friction loss may be compensated for by increasing the length of tubes so as to obtain sufficient additional evaporation to carry the greater load on the fan.

The point is often raised that tubular boilers are not so efficient as water-tube boilers. This is perfectly natural when only the usual types of tubular boilers and methods of using them are considered. As a matter of fact, the heating surface of tubular boilers can be made as effective or even more so than that of water-tube boilers. The trouble with the usual fire-tube boilers, especially when used for waste heat applications, is that the area for the passage of gases is too large and there is not sufficient length of travel for the gases. These objections are, of course, overcome by making a long boiler of smaller diameter, or, what amounts to the same thing, dividing the boiler into two or more passes. The matter of tube size is also a large factor and if the question of cleaning were not of such real importance, the tubes could to great advantage be as small as locomotive tubes, or even smaller.

Appreciating the above-mentioned advantages of the fire-tube boiler induced Mr. C. J. Bacon, formerly steam engineer at the South Chicago works of the Illinois Steel Company, to design a fire-tube type of boiler embodying the modern ideas of a waste-heat boiler.

The Bacon waste-heat boiler is designed to utilize at the maximum net economy the heat in waste gases from metallurgical and other industrial heating furnaces. It possesses special features that have been found to make it particularly well adaptable to the conditions peculiar to the majority of applications. The initial installations were in conjunction with open-hearth furnaces in steel works where the operating conditions and other limitations interfered with obtaining satisfactory results from standard types of boilers.

Obviously, in order that the first cost may be low and that the boiler may have the desired evaporative capacity, it is essential that the design contain such features as to permit condensing the heating surface into the smallest possible space. This in turn requires that the rate of heat transmission through the heating surface be proportionately high. Data resulting from various authoritative tests makes it possible to predict with accuracy what the heat transmission and, consequently, the evaporation will be. As usually built, the Bacon boiler consists of two vertical cylindrical shells, between the heads of which are rolled and electrically welded a large number of small tubes in a similar manner to vertical fire-tube boilers. The diameter of tubes is kept as small as permits cleaning and the length is determined mainly by the space available and the friction loss. The object is to insure that the gases have a long travel at high velocity. In some cases it is found desirable that the average velocity exceed 100 feet per second for the purpose of preventing dust from lodging and to give a high rate of heat transmission. The waste gases enter the gas box at the bottom of the first pass, whence they pass upward through the tubes and into the transfer flue which directs the flow downward through the second pass, and in the case of an installation recently finished a third pass, which will act as an economizer.

In some forms of construction of the Bacon boiler, a single shell is set horizontally and the two passes are obtained by suitable baffling in the steel gas boxes at the ends of the shell. For application to small furnaces, this is a better arrangement than the double vertical shell design.

Boiler scale trouble is minimized on account of feed water being admitted at the bottom of the second or "cold" pass. Here it becomes gradually heated and rises to the top of the pass. The water then passes from the second pass through an exterior water circulating connection to the bottom of the first or "hot" pass. As but one-third of the heat is utilized in the second pass, where gas temperatures at the bottom are not over 560 degrees F., the sludge deposited is not hard and may readily be blown off through the several blow-off connections. The principle of forced water circulation on a counter-current principle gives a high rate of heat transfer. Liberal hand-hole access is provided and blow-off valves are arranged to drain the bottom tube sheets.

As a rule, natural draft is not sufficient because the gases leaving the boilers have been cooled to 450 degrees or 500 degrees F. in the attempt to recover as much of the heat as possible. On this account and because the intensity of draft required for operating the industrial furnaces and for drawing the gases through the boiler, it becomes necessary to use induced draft fans. When properly installed and driven, the fans prove a very advantageous accessory from the standpoint of better control of the operation of the heating furnaces, and, with correctly selected turbine drive, the exhaust steam suffices to heat the boiler feed water.

While fans are a necessity regardless of the type of boiler used, the amount of power they require is much less with the fire-tube boiler than with water-tube boilers in brick settings. It is not at all unusual that the amount of air leakage through brick settings and other loose joints is sufficient to increase the fan load 80 per cent over what it would be without leakage. Moreover, the leakage reduced the evaporation to a serious extent, due to cooling the gases. Thus it is seen that a type of boiler having no brick settings is the logical solution of the air leakage problem. Casing the boilers in sheet steel reduces the trouble, but does not stop it since much leakage is past brick-to-mental joints. Moreover, it increases the cost of installation. The great difference in draft that exists in a baffled water-tube boiler on the two sides of the baffles causes short circuiting of gases, through leaky baffles, consequently lack of contact with tube surface and high stack temperatures. With fire-tube boilers trouble of air leakage from exterior or short circuiting of gases through baffles cannot occur. There is no brick work except linings of flues and gas boxes and these are of steel plate construction.

Explosions in the waste gas flues and in waste-heat boilers are characteristic of open-hearth furnaces using pre-heated gas. Leakage, especially, promotes explosions in the boiler setting at times of reversal. These explosions strain the settings, loosen the brickwork and increase the air leaks of water-tube settings. As an actual matter of fact, these leaks develop into serious conditions, particularly if repairs are not made promptly in every-day operation. Consequently, evaporation falls off continuously and it is a matter of record at many plants that air infiltration is such a serious factor that maintenance of economic steaming and furnace performance is a practical impossibility. Explosions cannot injure the fire-tube boiler.

Where the waste gases contain dust in a fine and adherent condition, it packs closely onto the tubes of the water-tube boilers. This is indifferently removed by mechanical soot blowers. Due to the high velocity of the gases causing a sweeping action, the dust does not readily collect on the surface of the vertical flues.

Another factor in favor of the fire-tube type of waste-heat boiler is for equal evaporation it requires but two-thirds to three-quarters the cubic space required by the water-tube type of boiler.

Source of Waste Gases.

In order to investigate the value and thereby the saving which may be made by utilizing the waste gases for the generation of steam it is, of course, necessary to determine the quantity and temperature of waste gas available.

A specific exhibit of the method in arriving at these quantities will, no doubt, aid those contemplating an investigation of waste heat recovery. The author has selected the open-hearth furnace as perhaps being the most difficult in determining the weight of gas available.

Source of Gases from an Open-Hearth Furnace
Typical Heat Data

Size of heat	75 tons (ingots)
Tons hot pig iron charged	42.75
Tons cold pig iron charged	.57
Tons iron scrap charged	6.10
Tons steel scrap charged	32.50
Pounds ore charged	14.200
Pounds limestone charged	15,100
Pounds dolomite charged	5,265
Pounds fluorspar charged	762
Pounds silicon (10 per cent) charged	262
Tons coal charged at producers	23.70
Time of heat	9 hr. 25 min.
CO content of waste gases	13.00 per cent
Tempt. of waste gases from checkers	1,300 deg. F.
Heat value of coal (Illinois)	10,000 Btu.
Percentage of pig iron	56.0
Percentage of scrap	36.8
Percentage of ore	7.2

The gas producing elements of the charge are the pig iron with 4.35 per cent carbon, 0.85 per cent silicon and 1.75 per cent manganese; the limestone with 42 per cent carbon dioxide, and the coal with the following analysis:

Analysis (Natural)

Carbon, per cent	60.10
Hydrogen, per cent	4.36
Nitrogen, per cent	1.18
Oxygen, per cent	10.97
Sulphur, per cent	1.42
Ash, per cent	8.43
Moisture, per cent	13.54

The steel scrap charged is considered a neutral component, being essentially of the carbon and metaloid content of the steel produced. The dolomite and fluorspar contribute negligible amounts of carbon dioxide to the gases. The ore charged, averaging 89 per cent ferric oxide, is significant in that the oxygen available therein for combining with the carbon of the pig iron reduces the amount of air with its nitrogen diluent, otherwise required for oxidation.

To reduce the data to pounds of gas per hour available for steam generation, the open-hearth practice must be reduced to the following figures:

Rate steel produced per hour....	7.96	tons ingots
Coal per ton ingots............	701	lbs.
Ore per ton ingots............	189	lbs.
Pig iron per ton ingots..........	1,475	lbs.
Limestone per ton ingots........	200	lbs.
Silicon	3.5	lbs.

Gas from pig iron charged per ton steel:

4.35 (carbon in pig iron) less 0.20 (carbon in steel)
= 4.15 percentage carbon burned out of pig iron
1475 × .0415 = 61.2 lbs. carbon burned out of pig iron
61.3 × 2.666 = 163.0 lbs. oxygen required for carbon
189 × 0.265 = 50.0 lbs. oxygen available in ore
163.0 — 50.0 = 113.0 lbs. oxygen required from air

$$\frac{113 \times .768}{.232} = 375$$ lbs. nitrogen in gas from accompanying oxygen.

61.2 + 163.1 = 224.3 lbs. CO_2 from pig in gas

Gas from limestone charged per ton steel:

200 × 0.42 = 84 lbs. CO_2

Gas from silicon and manganese charged per ton steel:

1.75 + .85 = 2.60 percentage silicon and manganese in pig iron
1475 × .026 = 38.5 lbs. Mn. and Si. in bath

$$\frac{38.5 \times 0.8 \times .768}{.232} = 102$$ lbs. nitrogen in waste gases from oxidation of Si. and Mn.

Total carbon dioxide from charge = 308 lbs.
Total nitrogen by charge = 477 lbs.

Gases from coal burned at producer:

$$11.52\ C + 34.56 \left(H - \frac{O}{8}\right) + 4.32\ S =$$

$$11.52 \times .601 + 34.56 \left(.0436 - \frac{.1097}{8}\right) \text{ plus } 4.32 \times .0142 = 8.01$$ lbs. air required per lb. coal

Analysis burned gases (0.0 per cent excess air):

CO_2 .601 × 3.67 = 2.2 lbs. CO_2
O_2
N_2 8.01 × .768 = 6.15 N_2 from air
.15 N_2 from coal
H_2O .0436 × 9 = .39 H_2O from H in coal
.1354 H_2O from coal
.07 H_2O from air 75% humidity
.50 H_2O from steam
9.59 total weight gas per 1-lb. coal
701 × 9.6 = 6,370 lbs. total weight gas from coal per ton ingots.

Per cent by weight:

	Wet	Dry
CO_2	22.85	25.8
N_2	65.75	74.2
H_2O	11.40	....

The CO_2 content of 13 per cent in the stack gases as compared to 19.2 per cent in gases from charge and coal undiluted with air indicates an addition of air of 47.5 per cent to the gases. This is, in part, supplied through the ports, and in part by leakage at the doors, ports and checkers. The indicated addition of 47.5 per cent air to 7,500 pounds gas will total 3,591 pounds of air per ton of ingots, giving 1,848 pounds CO_2, 833 pounds of oxygen, 7,651 pounds nitrogen, and 768 pounds moisture, or a total weight of gases of 11,100 pounds. Per hour we have 88,500 pounds of gas. As an approximate check on these quantities of gas, one may divide the total carbon in coal, pig iron and limestone, or 503 pounds, by the carbon in one cubic foot of waste gas containing 13 per cent CO_2, or 0.044 pound. This gives us 91,000 pounds per hour.

Analyses of Total Waste Gases—No Air Dilution Per Ton Ingots

Content	Lbs.	Total Lbs.	Analysis—Dry Weight	Analysis—Dry Volume
CO_2 from charge	308			
from coal	1540			
Total		1848	27.4%	19.2
N_2 from charge	477			
from coal and combustion	4416			
Total		4893	72.6%	80.8
H_2O from coal and steam....	768	768		
Total weight of gases per ton ingots		7509		

At 1,300 degrees F. there are 26,000,000 Btu. in the waste gases, as against 60,000,000 Btu. in coal charged, or 43 per cent of total heat charged, equivalent to 2,400 pounds of coal hour.

As an illustration of the practical application of the modern fire-tube type of waste heat boiler, a description and evaporation test of an installation follows:

Fire-Tube Waste Heat Boilers Installed on Open Hearth Furnaces.

The installation consists of fourteen (14) boilers, one Heine, two Stirling water-tube, and eleven (11) Bacon fire-tube boilers. A test was conducted on one Bacon fire-tube utilizing waste gases from an open-hearth furnace. Each unit consists of a superheater, a two-pass vertical fire-tube boiler, and an exhaust fan driven by a steam turbine.

The superheater consists of two units with elements set in a vertical position in the horizontal flue near the first pass of the boiler.

The boiler consists of two vertical passes 82 inches in diameter. The first pass contains 282 three-inch flues, 16 feet long, and the second having a like number, but 12 feet long. The tops of the two passes are set at the same height and each has a 16-inch nozzle located 12 inches from the top flue sheet and connected to a 4-foot 0-inch x 7-foot 0-inch steam drum. The bottom of the steam drum, which is about 30 inches below the top of the passes, is connected to each of the two passes near the bottom by a 12-inch water leg. Feed water enters this water leg from which it flows to the bottom connection of each pass. The water level is carried about 14 inches below the upper flue sheet. This gives about 92 per cent of the heating surface as effective for evaporation.

The second pass is equipped on top with a permanent soot blower, while a hand lance is used on the bottom of the first pass and superheater for cleaning flues.

The waste gases are handled by an overhung wheel single inlet fan. Capacity 80,000 pounds of gas per hour at 500 degrees F., with static difference of 5.5 inches at 1,115 rpm. Efficiency 75 per cent, requiring 37.5 hp. The fan is driven by a steam turbine, standard non-condensing 3,985 rpm rated 37.5 Bhp. The change of speed is made by a set of herringbone speed reduction gears of 3:57 to 1 ratio. The gases are taken from the main furnace flue, immediately before entering the stack, pass through a horizontal brick flue 4-feet 0-inches wide x 6-feet 9-inches high, equivalent to an area of 27 square feet, to the superheater, thence through the same sized flue to directly underneath the first pass, taken up through a 5-foot 3-inch diameter brick-lined flue and through the first pass, then across the transfer flue, down the second pass and out to the fan. The fan discharges the gases back into the main stack again immediately above the roof line. The boiler is equipped with suitable dampers before the superheater and after the fan to by-pass the boiler.

The feed water passes through a hot water continuous softener of 15,000 gallons per hour normal rating, located in the vicinity of the open hearth. The exhaust steam from the fan turbines and the three reciprocating feed pumps is used in heating the feed water while passing through the water softener.

Evaporation Test.

Feed water was measured in tanks of known dimensions and feed water temperature was taken with a thermometer. Tell-tale valves were installed in feed line to avoid any possible error in feed water piping. The blow-off valves all terminate in a pit and this was observed to correct any possible leakage. These valves were tightly closed and no leak found.

Temperatures of gases before the superheater, between the superheater and boiler, and between the two passes were taken with thermo-couples which were checked immediately before the tests. The temperature of gases between second pass and fan, also temperature of superheated steam, was taken with mercurial thermometer.

Drafts were taken with manometers and were checked frequently to avoid error with changes of temperature.

The steam consumption of the fan turbine was obtained by a recording steam flow meter installed in the 2½-inch steam line to the turbine. Each test was run from tap to tap of the furnace, but the first two hours of the last test were thrown out on account of having gas turned off for a few minutes due to furnace troubles. Table No. 1.

Soaking Pits and Re-Heating Furnaces.

Soaking pits and re-heating furnaces are other sources of waste heat recovery. The number, arrangement, and location of the pits and furnaces will determine the desirability and feasibility of an installation.

For example, the author has in mind one plant where there are ten (10) pits arranged in a row. Investigations made to determine the quantity and temperature of the waste gases demonstrated that with producer gas as fuel, there was available 26,000 pounds of waste gas per pit hour. The gas had an average temperature of 1,165 degrees F. at the base of the stack.

By an arrangement of underground insulated flues and suitable dampers such as to combine the gases from three or four pits to a boiler, it was estimated that 1,100 Bo. hp net would be developed based on 90 per cent operating time. The return on the investment in this case represented 45 per cent.

Table No. 1

Results of Tests

Date	June 14, 1918	July 1, 1918
Duration	9 hr. 55 min.	7 hr. 50 min.
Pressures—		
Steam at boiler—lbs. per sq. in.	144.6	143.5
Steam after superheater—lbs. per sq. in.	143.0	142.0
Loss through superheater—lbs. per sq. in.	1.6	1.5
Steam in turbine steam chest—lbs. per sq. in.	91.7	116.0
Exhaust steam from turbine—lbs. per sq. in.	0.0	0.0
Barometer—lbs. per sq. in.	14.45	14.5
Drafts—		
Before superheater—ins. water	1.45	1.26
Before boiler—ins. water	1.81	1.70
In transfer flue—ins. water	2.65	2.52
Before fan—ins. water	3.51	3.28
In fan discharge—ins. water	0.96	0.81
Drop in draft before superheater to fan inlet—ins. water	2.06	2.02
Drop in draft through superheater—ins. water	0.36	0.44
Drop in draft through first pass—ins. water	0.84	0.82
Drop in draft through second pass—ins. water	0.86	0.76
Drop in draft through boiler—ins. water	1.70	1.58
Total draft across fan—ins. water	2.55	2.47
Temperatures—		
Waste gas before superheater—deg. F.	1451.2	1372.6
Waste gas after superheater and before boiler—deg. F.	1269.4	1205.7
Waste gas in transfer flue—deg. F.	793.2	723.4
Waste gas before fan—deg. F.	556.2	525.0
Feed water—deg. F.	177.7	181.0
Steam leaving boiler—deg. F.	363.0	362.0
Steam leaving superheater—deg. F.	507.0	472.0
Superheat—		
Due to boiler—deg. F.	0	0
Due to superheater—deg. F.	145.0	110.0
Total superheat—deg. F.	145.0	110.0
Calorimeter—		
Temperature of steam—deg. F.	296.65	314.6
Pressure of steam—ins. hg	4.42	4.81
Quality of steam—per cent	99.5	100.0

	—June 14, 1918—		—July 1, 1918—	
Water—	Bo. Only	Bo. & Suphtr.	Bo. Only	Bo. & Suphtr.
Water per Hour—				
Total fed to boiler	129,685	129,685	100,990	100,990
Factor of evaporation	1.081	1.162	1.077	1.134
Equiv. evap. F. & A. at 212°	140,200	150,700	108,600	114,500
Fed to boiler—lbs.	13,086	13,086	12,890	12,890
Equiv. evap.—lbs.	14,150	15,210	13,885	14,630
Horsepower	410	441	403	424
Net Bo. hp deducting turbine steam	371.3	402.3	364	385

	—June 14, 1918—		—July 1, 1918—	
Gas Analysis—	Before Suphtr.	Before Fan	Before Suphtr.	Before Fan
CO_2—per cent	14.20	12.48	14.5	12.1
O_2—per cent	5.61	7.17	5.4	7.0
CO—per cent	0.0	0.0	0.0	0.0

	June 14, 1918	July 1, 1918
Opening of damper to stack—(average)	0	0
Steam per hour to turbine—lbs.	1148	1205
Boiler hp of turbine	38.7	39
Turbine speed—rpm	3486	3589
Density of gas at 62° F.—lbs	.07893	.07893
Heat absorbed from gases by steam per hr. Btu.	13,730,000	13,492,000
Coal equivalent lbs. per hour	1250	1220
Heat radiated per hour—Btu. (assumed)	500,000	500,000
Total heat absorbed and radiated—Btu.	14,230,000	13,992,000
Total tempt. drop across boiler—deg. F.	713.2	680.7
Weight gases per hr. through boiler—lbs.	79,800	82,300
Evaporation in first pass—per cent	67	70.8
Evaporation in second pass—per cent	33	29.2
Per cent drop in tempt. between inlet and outlet of available heat	78.7	80.7
Rate of heat transfer, Btu. per hr. per sq. ft. of heating surface per degree mean tempt. difference between gas and steam	5.93	6.31

In making an investigation, as mentioned above, to determine the quantity and temperature of gases available, precautions should be taken to stop all unnecessary cracks and openings around valves, and in the flues leading to the point of observation. Otherwise, determinations made would not represent the condition which might be obtained. As, for example, when observations were first taken, it was found that the stack temperatures only averaged in the neighborhood of 825 degrees F. This difference of temperature was, of course, due to air infiltration, while not in this particular case affecting the economic operation of the pit, would lead to erroneous conclusions from the standpoint of waste heat utilization.

The following is a drawing showing a proposed installation of waste heat boilers for soaking pits.

Electrification of the Steel Plant Railroad

By R. B. GERHARDT.

"ELECTRIFICATION of main line railroads in this country, up to the present time, has, in general, been for special purposes, such as to relieve congestion or for terminal work. Only a very few roads have electrified with the view of handling general freight and passenger traffic."

"There are four reasons for electrification at the present time; these are as follows:

1. Tunnel Electrification.
2. Terminal Congestion (also smoke nuisance).
3. Grades.
4. General Economies and Increased Capacity."

"Some of the roads which are electrified for tunnel work only are the Boston and Maine (Hoosac Tunnel), the Grand Trunk R. R. (St. Clair Tunnel), The Great Northern R. R. (Cascade Tunnel), and the Michigan Central (Detroit River Tunnel)."

"Some of the roads which have electrified terminals in order to reduce congestion and smoke nuisance in the approaching tunnels are the New York, New Haven & Hartford R. R., the Pennsylvania R. R. (at New York and at Philadelphia), the New York Central, and the Baltimore and Ohio."

"Roads which have electrified primarily on account of grades are the Norfolk & Western and the Chicago, Milwaukee & St. Paul."

"Roads which have electrified in order to obtain the general economies resulting therefrom together with increased capacity are the New York, New Haven & Hartford, the Norfolk & Western, Chicago, Milwaukee & St. Paul, and the Butte, Anaconda & Pacific. As may be observed, there are only four main roads as yet electrified which haul general traffic. The other electrifications are of such a nature that there is no opportunity for classifying or switching of any considerable amount of freight. However, it is interesting to know that a number of the roads have had projects under way for the electrification of classification yard, the chief of which are the Pennsylvania R. R. (the new freight yard between Fifty-second and Overbrook, just outside of Philadelphia), and the Baltimore & Ohio (at Cumberland)."

"It is also interesting to note that a large number of smaller railroads handle and switch freight by electric locomotives. Some of these roads are:

Southern Pacific (Pacific Electric), Oakland, Antioch & Eastern, Piedmont & Northern, Spokane & Inland Empire, Salt Lake & Utah, Fort Dodge, Des Moines & Southern."

In practically all cases where roads have been electrified a considerable economy of operation has resulted and in all cases the electrification has permitted of more dense traffic than previously.

Considering the electrification of steam railroads in general, the following items as regards economy of operation, in addition to the fixed charges on any investment undertaken, have to be considered:

Fuel and other operating materials
Repairs
Operating Labor
Locomotive Depreciation
Hostler or Station Service.

Fuel.

Under this item the greatest saving can be shown in yard service, due to the fact that the steam locomotive in yard service is idle a much longer time than in any other class of service, and during this time the losses, figured back into fuel are very considerably greater than with the electric locomotive, particularly where the energy for such electric locomotive is obtained from a general system of power. It has been pointed out also, under this heading, "that there is no creeping paralysis gradually impairing the efficiency of the electric locomotive until temporary relief is obtained through frequent boiler washings and shifter house tinkering, as the efficiency of this unit remains very nearly constant over the entire life of the equipment." In addition to the above the steam locomotive efficiency gradually drops off from wear in the piston rings, piston and cylinder walls. With electric operation, however, there are some chances of inefficient operation due to transmission, distribution and track bonding losses, and it is essential that careful inspection be given these points the same as is given the locomotive itself. From results obtained by the N. Y., N. H. & H. Railroad Company it has been shown that for every 106.8 pounds of coal required by a steam locomotive in yard service, 38.3 pounds of coal will do the same work after electrification. (Refer to joint meeting of A. S. M. E. and A. I. E. E., New York, October 22, 1920. Statement A. L. Ralston, Mechanical Superintendent, New York, New Haven & Hartford Railroad.) This gives a ratio of 36 per cent for this class of service, but for yard work recent tests have shown that this ratio drops to 18 per cent, not taking into account coal lost in the steam locomotives

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Abstract of paper read at Association of Iron and Steel Electrical Engineers Convention, Chicago, September, 1921.

by banking the fires. With electric locomotives receiving their energy from a central power system the cost of electric power has to be compared with the cost of fuel for the steam locomotive. However, there is no coal and ashes to be handled, likewise, in the case of yard service no water. There is, however, some operating material, such as oil, grease and sand required in both cases, but the items of oil and grease are much less with the electric locomotive. Along with the elimination of fuel, ashes, and water, there can be discarded, in favor of electrification, the plants required to handle these materials.

Repairs.

Under this item the fundamental difference between the two classes of locomotives is the length of time required to make any major repairs, except possibly in the cases of turning tires and painting. Spare parts can be so easily and quickly substituted in the case of the electric locomotives, that the time for so doing will greatly overbalance that required for most repairs on the steam locomotive. An armature, motor, gear, or controller on the electric locomotive can almost be changed in the time required to cool down and empty a locomotive boiler safely for any boiler repairs, not to speak of engine cylinder repairs. With electric operation where power is taken from the general power system, the cost of any additional apparatus required for supplying current to electric locomotives, of course, has to be taken into account; likewise, an item under repairs to be considered, which does not enter into steam operation, is the maintenance of transmission, distribution and contact line systems. With electric locomotives, however, there are no restrictions imposed by any outside boiler inspection. The following figures, taken from Mr. Armstrong's paper at the New York Engineering Meeting, referred to above, are indicative of the locomotive cost on repairs for main line freight service:

Operating Labor.

	Steam Mallet	C., M. & St. P. Electric
Cost repairs per mile...........	60 cents	14 65 cents
Weight on drivers..............	240 tons	225 tons
Cost repairs per 100 tons locomotive weight on drivers.....	25 cents	6 25 cents

In general yard work the train crews under electric operation do not differ from those under steam operation, except that the wages of the man taking the place of the fireman are usually somewhat less. For steel plant operation considerable additional economy can be effected.

Locomotive Depreciation and Retirement.

In the case of steam it is at an appreciably higher rate than in the case of electric operation. It is generally conceded that the life of a steam locomotive averages between 15 and 20 years, as against the life of an electric locomotive of 25 to 30 years. Substantiating this I wish to point out that the electric locomotives on the B. & O. Tunnel, in Baltimore, are already in their twenty-sixth year of operation.

Hostler or Station Service.

With electric operation this service is reduced almost to a minimum. As a matter of fact if the locomotives are so designed as to allow liberal accessibility for inspection and oiling, the inspector can look after his work without necessitating the locomotive being sent to the station or shop, and the only requisite in the usual course of operation would be that the locomotive go to a specified point for taking on sand when the supply is exhausted. No fire cleaning and rebuilding is necessary; likewise, fueling, watering and washing are done away with. The electric locomotive is always ready to run and pull its maximum load with the turning on of the curent. While it is first necessary with the steam locomotive to get up steam pressure to do this work.

In the above conditions the electric storage battery type of locomotive has not been included for the reason that a greater saving of electric operation over steam is shown by the use of straight electric locomotives only. If the storage battery machine is considered each of the above items would be increased over straight electric locomotive operation except the item—"Operating Labor." For yard work the storage battery machine, especially since the same can now be secured in fairly large size units, offers attractive possibilities due to the fact that no overhead or rail contact systems are required for its operation. However, the disadvantages are its not being able to withstand as rough treatment as the straight electric machine, its inability to maintain continuous service since during certain periods it must be idle for charging the battery or else exchanging batteries, and finally a high depreciation on the battery itself. A combination machine using both line contact system and battery may be used and considerable benefits derived over the straight battery machine.

Practically all of the steel plants with which we are familiar use for their dc power system direct current at a potential of 250 volts, and it is very essential for simplicity and economy to use this same potential for the electric locomotive. In most plants it should be entirely feasible to do this for the reason that dc generating or converting apparatus is so distributed that long distances of transmission are not encountered. In many cases the combination of the general plant load, which is highly diversified, due to crane and mill operations, with the railway load will considerably improve the load factor of the dc apparatus so that to handle the yard electrification it would not be necessary to install such apparatus to the full capacity required for this work.

The principal objection to the overhead trolley in the electrification of our yards is from the interference with the work of locomotive cranes. This machine is so essential in the steel plant yard that it is almost impossible to pick out any section of track where the crane will not be required to work at some time or other; otherwise, we might consider the overhead construction, except in specified places where locomotive crane work is concentrated. It may be proved, however, that such construction can be used to advantage in the general classification yards, and this is a matter for further study. One other objection to the overhead trolley is that it does not lend itself very readily to heavy operation at as low a voltage as we propose to use, and we, therefore, feel that the most satisfactory system would be the third rail. After reaching this conclusion the first question that naturally presents itself is the feasibility of a third rail in the yard from the following standpoints:

1. Safety.
2. Blocking the free passage of switchmen or other employees through the yard.
3. Danger from material or hot metal spilling or falling on rail.

4. Methods of crossing frogs and switches.
5. Method of construction through buildings or special places where conductor rail is objectionable.
6. Tie-up from wrecks.

Safety.

The best answer to the question of safety is to refer to the operation on blast furnace trestles where we have had electrified tracks with third rail construction for many years, operating at the same voltage as proposed for yard electrification. Looking over our records during this time I find that there has not been a single accident from contact with the live rail. There have been accidents on the trestle due to other causes, but none can be attributed to the electrified condition of these tracks. Two hundred and fifty volts is the common plant voltage which our workmen are thoroughly familiar with, and particularly the yard department employees who have anything to do with locomotive cranes or handling of lifting magnets. If we would have to go to any higher voltage, then the proposition would be considerably more hazardous. There are essentially two kinds of third rail contact systems, one using the over-top contact and the other underneath contact, and we prefer the latter for steel plant work due to the fact that it can be better insulated and more substantially protected from material falling into the rail and causing any trouble. With this type of construction, it is almost impossible for anyone to come into contact with the live rail, except by getting down underneath of the guard on either side and touching the head of the rail, which extends slightly below the guard; whereas, with the overtop contact there is not formed nearly as good a support for the guard and anyone stepping on this guard or anything falling on same is very apt to break through and come in contact with the live rail, also it is entirely possible to come in contact with the rail from the side toward the track which is entirely exposed. The underneath contact system lends itself more readily to a very close fitting guard, thus taking up considerably less space than the overtop contact rail with guard, and this close fitting guard can be purchased on the market made up of impregnated insulating material in sectional lengths which fit the rail exactly and require no supporting straps or brackets. The labor of installing or repairing such guard is, therefore, reduced to a minimum. Such construction has been in satisfactory use for quite a number of years on the New York Central electrification in New York City, also on the Philadelphia Rapid Transit System. Other installations are New York State Railways, Michigan Central Railroad, and the Central California Traction Company, as well as several industrial plants.

Blocking Free Passage of Switchmen or Other Employees Through the Yard.

The type of third rail construction described above makes it very feasible to step over the rail without hazard of shock and without any strenuous effort. Also in crossing the rail there is no danger in actually stepping on the guard which will easily support just as much weight as the rail itself. At any point where it is desirable to do so a gap of approximately 40 feet can be left in the rail without interfering in any way with operation. Thus at road crossings there will be no difficulty, and at an other necessary points such gaps can be allowed. Where two or more tracks run parallel the conductors' rails are located toward the inside of these tracks, so as to leave the outside area free of obstructions to the switchmen and brakemen. With electric operation the locomotive has operating control equipment on each side of the engineer's cab so that he can use either side of the locomotive as desired.

Methods of Crossing Frogs and Switches.

On a general first glance at a steel plant railroad yard one's first opinion is that on account of the complicated track system with numerous switches and crossovers, third rail operation is not practical. However, one only needs to study the situation to a slight extent to overcome these doubts. On many furnace trestle electrified tracks we have solved these difficulties and can easily improve even on such systems, as there are considerable difficulties to contend with there, due to spillage of all kinds of raw materials and scrap down over the tracks, which would not be the case in general yard work. By using four collector shoes, one at each corner of an electric locomotive, and by the use of the side approach conductor rail fitting at switches, it is entirely possible to keep current on the locomotive, even at most difficult track positions, and where gaps must necessarily occur in the conductor rail it is only a matter of getting the proper distance between collector shoes to solve the problem.

For the purpose of making a comparison between steam and electric operation on any particular proposition it is very necessary for accurate results to secure a service data test on one or more of the steam locomotives to be replaced in each class of service. For conducting this test the locomotive is equipped with an electric revolution counter for determining the speed and the distance travelled for any movement. The time is taken with a stop watch, the weights of the cars obtained from the freight records, and a log is kept as follows:

The revolution counter is read and recorded, and as the locomotive starts to move the time is taken, together with the trailing load, until the locomotive is stopped. These values are recorded opposite the counter readings. A new counter reading is not taken until the load is changed, by either dropping or taking on cars. Only the seconds in motion are recorded. If locomotive is stopped for switches, etc., the time it is standing still is deducted from the total time of the move. When the load is changed, this constitutes a new shift and counter is read, and recorded under shift No. 2. The new load and time of the new shift is termed a light shift or running light move. The same record is kept of these moves as of loaded shifts. In keeping this log for a day the total work done by the locomotive for that day can be determined in terms of ton miles. The coal consumed per day is taken from the coal records so that pounds of coal per ton mile can be obtained. In order to arrive at a more reliable average day's work, three tests are made and their averages taken as a normal day's work on each particular application.

The following sample table gives data on a steel mill yard locomotive in typical service of handling incoming and outgoing freight. This work is of a variable nature as cars are spotted and collected all over the yard:

This table shows that the heaviest trailing load handled during the three days was 1,330.5 tons, while most of the work consisted of considerably lighter shifts. The number of shifts per day is 88, while the per cent of time idle, lost in throwing switches, and making couplings, is only 40 per cent of total time. From comparison with other tests, it has been found that a locomotive working its maximum all day will vary its per cent time lost inversely with its length of shift. The average length of shift on this work was 1,682 feet. With this length of shift and size of locomotive, 40 per cent time lost represents a full day's work or as much as can be expected from locomotive so far as movement is concerned. Since the average load was only 199 tons, the trailing load could have been larger and more work or ton miles could have been accomplished, but the time lost would have remained no less and probably some greater. The total mileage per day averages 26.6 miles, which gives the average speed per shift at 5.1 mph. The trailing ton miles, which represent the effctive work accomplished by the locomotive, were 3,530.4, while the locomotive ton miles or tons miles expended in order to accomplish the effect or trailing ton miles were 3,064. The locomotive ton miles represent 46.5 per cent of the gross or total ton miles. As the locomotive ton miles are ineffctive ton miles, the shifting may be said to be only 53.5 per cent efficient. The tender ton miles average 1,010.3 ton miles and are the ton miles necessary only to supply fuel to locomotive. Trailing ton miles should be used as a basis for any calculations since this value is the effective work, hence the amount of coal used to accomplish a trailing ton mile was 1,122 pounds.

Incoming and Outgoing Freight—Locomotive No. 26
Weight on drivers, 75 tons. Total weight, 115 tons.

Test No.	1	2	3	Average
Date of test	2/8/21	2/9/21	2/10/21	3 Days
Length of test—hours and minutes	7:11	7:10	7:27	7:16
Time locomotive was in motion	4:12	4:02	4:53	4:21
Time idle and lost coupling	2:59	3:08	3:34	2:55
Per cent time idle and lost in coupling	41.6%	43.8%	34.4%	50%
Number shifts per day	116	70	77	88
Number shifts light per day	14	14	16	15
Average length of shift—feet	1,180	1,925	1,940	1,682
Average speed per shift in motion	5.1	4.9	5.2	5.1
Maximum average speed—M. P. H.	10.6	9.4	10.6	...
Average weight trailing load	143.3	180.5	273.0	198.9
Average weight of loaded train	258.3	295.5	388.0	313.9
Per cent locomotive weight to total train weight	44.6%	39.0%	29.7%	36.7%
Maximum trailing load (tons)	481.5	907.95	1,330.5	...
Total distance per test (miles)	25.95	25.48	28.29	26.57
Total distance light (miles)	7.24	8.38	10.63	8.75
Per cent total distance light	27.9%	32.9%	37.6%	32.9%
Trailing tons miles per test	2,681.3	3,088.2	4,821.8	3,530.4
Tender ton miles per test	950.5	949.2	1,131.4	1,010.3
Locomotive ton miles (tender inclusive)	3,008.4	2,930.2	3,253.4	3,064.0
Gross tons miles per test	5,689.7	6,018.4	8,075.2	6,596.0
Pounds coal per test	3,960	3,960	3,960	3,960
Pounds coal per Tr. ton mile	1.477	1.282	.823	1.122
Pounds coal per Gr. ton mile	.696	.658	.591	.615

In order to give some idea as to what results might be secured after electrification the figures below are representative of a case which the writer has had under study for some time past and gives actual steam operation costs averaged over a period of several years against estimated costs with electric operation:

	—Steam—	—Electric—	
		Battery Locomotives	Straight Electric With Third Rail
Number of locomotives	27	27	23
Investment charges, including shop and service facilities, converting apparatus, transmission and contact systems	$850,000.00	$1,220,000.00	$1,376,000.00
Fixed charges per annum	99,300.00	105,300.00	164,800.00
Locomotive depreciation	20,400.00	163,400.00	23,700.00
Fuel or power	116,100.00	28,000.00	18,900.00
Repairs	140,700.00	36,000.00	28,800.00
Operating labor	147,500.00	89,500.00	89,500.00
Station service including miscellaneous operating material	43,000.00	16,000.00	9,400.00
Totals	$567,000.00	$ 438,200.00	$ 335,100.00
Annual saving over steam		$ 128,800.00	$ 231,900.00
Per cent return on investment in addition to normal interest included in fixed charges		10.5%	16.9%

This proposition covers a steel plant railroad yard having a total trackage of 57 miles of single track. There are a total of 27 steam locomotives ranging in size from 75 tons down to 25 tons, and it is assumed that 27 battery locomotives with extra battery units, or 23 straight electric locomotives, using third rail would be required to do the same work. For standardization purposes and flexibility of operation it is assumed that electric locomotives would either be 40-ton or 80-ton units; each of the latter being made up of two of the 40-ton machines. This would mean a total of 37 of the 40-ton battery locomotives or 33 of the 40-ton straight locomotives to be considered. The figures given under electrification for investment charges really represent the net cost of this work after an allowance has been made for the salvage value of the steam locomotives displaced.

These figures really show only part of the saving that can be made by electrification. After the yard is electrified (with third rail system) the next step is to equip the locomotive cranes for motor operation and these machines could work in any part of the yard through the full 24 hours of the day if so desired. The greatest item of saving in this case shows up in the additional amount of work which can be secured from these units, for with steam operation present experience has shown that a general average of 50 per cent of the time is lost due to the cranes having to drop their work and go for fuel or water. In some cases it is true that these items can be secured without any great movement, and in other cases many hours are lost for the same purpose, but in either event it is true that the cranes cannot continue with their work while taking on these requirements. It is rather hard to figure just what saving can be effected without making an extensive investigation over quite a period of time, but for the case cited it is estimated that $70,000.00 annually would be conservative for an average of ten cranes in operation. This would bring the annual saving in favor of electrification up to over $300,000.00 cutting the cost over the present method of operation by almost one-half.

It would appear, therefore, that the general subject of electrification of the steel plant railroad is one which merits our investigations and study, and the writer predicts that the electric motor will displace the steam engine on our transportation system just the same as it has in our rolling mills.

Electric Drive for Small Automatic Self-Dumping Skip Hoists

Field of Usefulness of This Type Hoist Could Be Extended if Their Limitations Were Studied and Means of Improving Their Characteristics Were Pointed Out from the Standpoint of Power Application.

By R. H. McLAIN and C. B. CONNELY,

SMALL automatic self-dumping skip hoists are generally used for ash removal and coal hoisting in power plants and railway locomotive coal stations, and in handling free-flowing bulk material of various kinds. It is believed that their field of usefulness could be further extended if their limitations were studied and means of improving their characteristics were pointed out from the standpoint of power application.

There are three general classes of self-dumping skip hoists. All are equipped with a special bucket which, when drawn into cams at the top, either tilts over and discharges from its top or opens and discharges at the side and bottom, and then rights itself when lowered back into the skip shaft.

Class 1 is the unbalanced skip hoist, and its requirements are:

(a) Power for hoisting a full skip.
(b) Power for hoisting an empty skip.
(c) Brake for lowering an empty skip.
(d) Brake for lowering a full skip.

Class 2 is the counter-weighted skip hoist. The counter-weight may be of any value, but for purposes of this article it will be considered to be equal to 100 per cent of the skip plus 60 per cent of the material in the skip. Its power requirements are:

(a) Power for hoisting a full bucket.
(b) Brake for hoisting an empty bucket.
(c) Power for lowering an empty bucket.
(d) Brake for lowering a full bucket.

Class 3 is the balanced skip hoist. It consists of two dumping skips and skip-ways, one of which is lowering while the other is hoisting. The power requirements are:

(a) Power for hoisting a full skip and lowering an empty skip.
(b) Power for hoisting a full skip and lowering a full skip.
(c) Power for hoisting an empty skip and lowering an empty skip.
(d) Brake for hoisting an empty skip and lowering a full skip.

The rope pulls change while material is being dumped and while some of the weight of the top skip may be resting on the dumping cams, and Figs. 1 to 9 inclusive are plotted to show the motor torque required for Class 3 hoists under conditions (a), (c) and (d), it being assumed that speed is constant. These curves are plotted

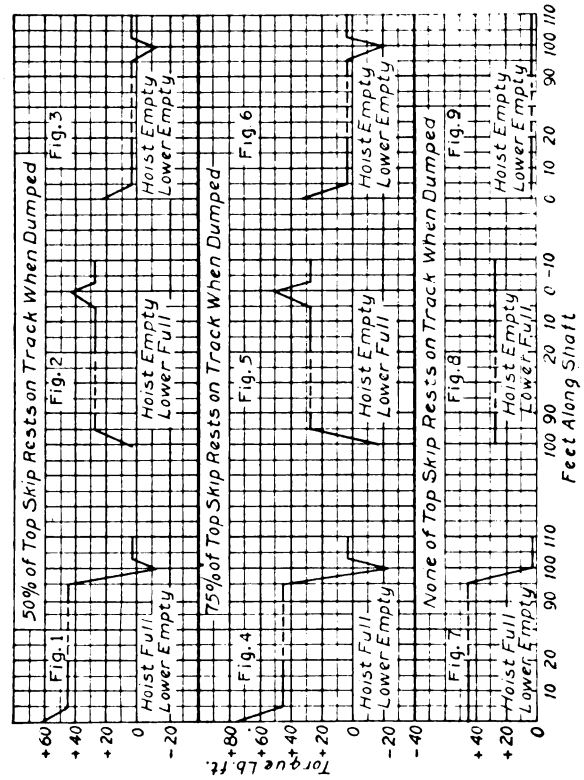

Fig. 1 to 9—Typical rope pulls of balanced hoists expressed in lb.ft. torque at motor shaft.

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with motor torque as ordinates and feet along the skipway as abscissae.

Drums are cylindrical.
Weight of skip 100 per cent.
Weight of material in skip 100 per cent.
Weight of counter-weight (when used) 169 per cent.
Motor speed 900 r.p.m.
Height of hoist 100 feet.
Weight of rope is neglected.

Normal amount of rope drawn in when skip is being pulled into the dumping cams is 5 ft.

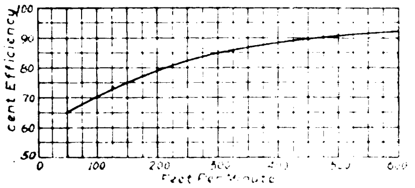

Fig. 10—Theoretical skip hoisting engine efficiency from motor shaft to rope.

The skip or counter-weight when at the bottom is suspended entirely on the rope; also the counter-weight when at the top is suspended entirely on the rope. A variation in this arrangement can easily be made by allowing some of the weight of the skip at the bottom to rest either on a weigh-beam or a cam-shaped track. Such an arrangement can be made to materially improve the duty cycle, especially as regards accuracy of stopping and amount of starting torque. (Figs. 7, 8 and 9, while not plotted to cover this condition accurately, illustrate the nature of the advantage obtained.)

When the skip is in the normal fully dumped position at the top, either 100 per cent, 50 per cent or 25 per cent of the weight of the skip may be suspended from the rope, the remainder resting on the dumping cams. The amount of weight which hangs on the rope depends upon the type of bucket and cams. Distinction will be made between the duty cycles under each of the three conditions. When the skip is drawn three feet of rope travel above the normal position of dumping, 100 per cent of the weight of the skip is suspended from the rope.

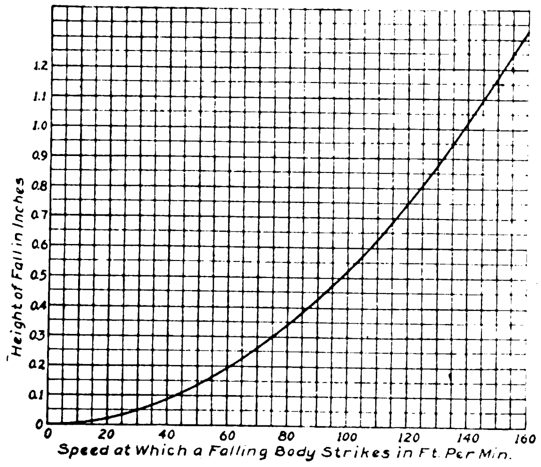

Fig. 11—Speed at which a falling body strikes versus height of fall in inches.

The losses in sheaves and the shaft friction for a skip are taken as 3 per cent of the rope pull produced by that skip in a vertical shaft.

The mechanical efficiency of the hoisting machine between motor pinion and rope is taken as 85 per cent.

An additional set of curves, Figs. 12 and 13, are plotted to show how great is the variation in the point of stopping both at the top and at the bottom when certain of these conditions vary. In this set of curves the variation of the stopping point in feet is plotted as ordinates against the skip speed in feet per minute as abscissae. These variations are caused by the following variations in hoist conditions, which are now used to supersede certain assumptions made above:

The hoist machine efficiency will now be taken as 65 per cent for 50 ft. per minute speed, and will vary up to 85 per cent for 300 ft. per minute skip speed, as shown on Fig. 10.

References to Tables I and II will show that speeds ranging from 95 per cent of synchronism for hoisting to 124 per cent for lowering, and 95 per cent for hoisting to 113 per cent for lowering, were used to cover variations due to voltage and load conditions and to the class of motor considered.

A wound rotor polyphase induction motor with the armature short circuited and with normal voltage has a full load speed 95 per cent of no load speed.

It takes one-fifth of a second for a friction brake to begin actual retardation after a stop limit switch has tripped. This assumption makes allowance for the time required to open the circuit to a contactor plus the time for it to drop open, plus the time for the circuit through the contactor to be broken, plus the time required for the brake core to move from the released to the applied position.

The acceleration of the armature and all other moving parts is assumed to require during one second 100 per cent of the torque required to hoist normal load at normal speed up the straight part of the shaft.

Voltage will be assumed to be 105 per cent maximum and 90 per cent minimum, and for each condition the particular voltage value will be chosen which tends to make the widest variation in speed. This will mean that the motor speed varies from 95 per cent to 124 per cent of synchronism.

The torque produced by the friction brake will be assumed to be somewhere between 125 per cent and 150 per cent. The value which produces the widest variation in landing accuracy will be used.

From Figs. 12 and 13 it is easy to determine the cage speed at which a hoist can be operated for any desired accuracy of landing. But these curves, as shown by foregoing assumptions, picture the conditions of what might be called an ordinary installation where no refinements were used to improve the accuracy of the landing.

The Tables I and II, which refer to Figs. 12 and 13, indicate that much greater accuracy of landing may be obtained by adopting improved methods, as follows:

1. Use a heavier solenoid brake whose maximum retarding torque is 200 per cent of torque required to hoist full load at full speed and minimum retarding torque is 166 per cent.

2. Provide means in the control apparatus which will eliminate entirely the time interval between the shutting off of power from the motor and the beginning of retarding torque by the brake.

3. Use a motor which has a speed ratio of 2:1, that is, it can be slowed down from a maximum speed to one-half maximum speed before the final stop is made. Such a motor would have approximately 20 per cent more

flywheel effect in its armature than would a single speed motor.

4. Use a slip ring induction motor in which all resistance is short circuited while hoisting, thus insuring a range in motor speed between 96 per cent and 114 per cent.

Tables I and II indicate by percentage the relative accuracy of these various expedients. The conditions shown by Fig. 12 are taken as 100 per cent for Table I and those shown by 13 are taken as 100 per cent for Table II. For example: In Fig. 12, the variation in stopping for a skip whose full load normal speed is 300 ft .per minute will be 6.9 ft. Now, by referring to Table I, it will be seen that this condition is considered as 100 per cent, and if the control is arranged to take the lag out of the brake, this variation will be 47.7 per cent of 6.9 ft., or 3.3 ft. If this time element is taken out of the setting of the solenoid brake, and if the brake is increased so that its retarding torque varies between 166 per cent and 200 per cent of normal torque, the variation now becomes 25.3 per cent of 6.9 ft., or 1.74 ft. If a still further improvement is made by using a 2.1 adjustable speed motor having a small slip, and the large brake is still used, the variation will be 6.2 per cent of 6.9 ft., or 0.43 ft. In other words, by introducing several refinements a very high degree of accuracy can be obtained.

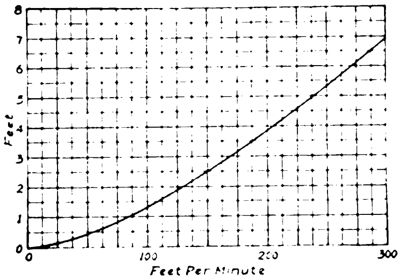

Fig. 12—Variation in stopping in feet versus normal hoisting speed under following conditions.

As indicated above, one method of improving the accuracy of landing is the use of a 2:1 adjustable speed motor which is slowed down to a creeping speed for approaching the landing point.

There are three other conditions besides accuracy of stopping which will determine the value of this creeping speed, viz.: first, the speed at which the skip may be permitted to enter the dumping horns because of strains in the structure when the vertical velocity of the skip is changed to horizontal velocity; second, the speed at which material may be permitted to spill as determined by its disposition in the receptacle into which it falls; third, the speed at which the skip may strike the scale beam at the bottom when such a beam is used. No attempt will be made in this paper to prescribe these limits because they depend on conditions other than power drive, but Fig. 11 is submitted as an aid in judging the speed. The accuracy required for landing is most frequently the cause of speed limitation.

Don't use series wound direct-current motors except on Class I hoist.

Don't use compound-wound direct-current motors except on Class I hoist, unless the series field is short circuited by the starting controller.

Don't insert resistance in the armature circuit of a direct-current motor or an alternating current motor and expect this to improve the accuracy of landing. Under normal conditions it may diminish the speed at which the skip enters the dumping horns, but it increases the variation in stopping accuracy and under abnormal conditions of load, such as hoisting an empty skip and lowering a full skip, it increases the speed at which the skip enters the dumping horns. The only sure method with cylindrical drums* of getting a dependable decrease in speed for dumping and landing purposes is to use dynamic braking or shunt field control in the case of d. c. motors, or multi-speed windings in the case of a. c. motors.

TABLE I
For Class 3 Skips

When hoisting an empty bucket and lowering a loaded one the per cent variation from the stopping distance in Fig. 12 is given below:

Motor Speed Range	2:1			1:1			Pct. Wt. of Skip on Rails in Dumping.
Variation from Snych.	95-113 Per Cent		95-124 Per Cent	95-124 Per Cent			
Brake Per Cent	150-125	200-166	150-125	150-125	200-166		
Percentage Variation from Fig. 12							
			18	72.		A	
	9.43			41.	22.6	B	5
			30	100.		A	
	17.	6.2		47.7	25.3	B	50
			31	102.		A	
	31.5	7.73		53.3	28.1	B	75

A indicates variation allowing 0.2 seconds after power shut off before brake applies.

B indicates variation when braking commences instantly after power cut off.

TABLE II
For Class 3 Skips

When hoisting an empty bucket and lowering an empty one the per cent variation from the stopping distance in Fig. 13 is given below:

Motor speed range	2:1	1:1			Pct. Wt. of Skip on Rails in Dumping.
Variation from Synch.	95-124 Per Cent	95-124 Per Cent			
Brake per cent..	150-125	150-125	200-166		
	9.76	54.7		A	
		41.3	22.7	B	0
	9.88	100.		A	
				B	50
	24.3	113.		A	75

A indicates variation allowing 0.2 seconds after power shut off before brake applies.

B indicates variation when braking commences instantly after power cut off.

In order to render these skip hoists automatic in action it is necessary to use full magnetic control, and along with this should be provided overload protection. Sometimes no voltage protection is also necessary, but in other cases it is perfectly proper for the hoist to resume operation as soon as power is returned. In the case of a.c. motors protection should be provided against an accidental reversal of the phase rotation in the power supply. This can be done either by the use of a reverse-phase relay or by special arrangement and connection of limit switches. Some trouble may be encountered from a reversal of incoming power, as the skip may start down with a wrong condition of load and this may cause trouble, or it might injure someone who had every reason to believe that the skip was going to start in the normal direction and had placed himself in a dangerous position. A phase reversal relay will protect against either of these troubles. Another trouble is that the usual method of connecting limit switches protects against over-travel only when the normal up contactor will stop the cage from going in the up direction, but under conditions of phase reversal the up contactor would not control the motion of the up direction. Consequently an elaborate arrangement of limit switches or a phase reversal relay is required to protect against such an emergency. A slack cable switch for stopping the hoist, should a cable become slack around the drum indicating that it was broken or that a skip had been obstructed in the shaft, would protect against trouble.

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*Conical drums can be made to decrease the ship speed even when motor speed is constant.

Automatic control may be made to perform any of the following functions:

(a) An attendant starts the skip from the bottom and it is hoisted to the top where it is automatically dumped and stopped. It does not move again until an attendant starts it, and it goes through this cycle each time an attendant starts it. Such an equipment requires a push button for starting up, a push button for starting down, a stop switch, and the necessary limit switches for slowing down and stopping at each end of travel.

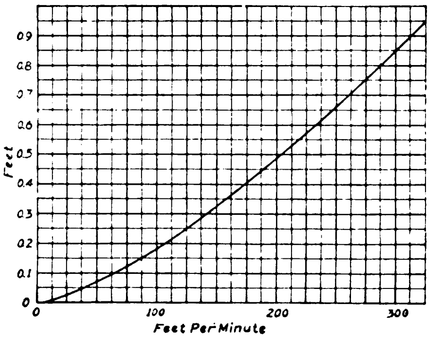

Fig. 13—Variation in stopping in feet versus normal hoisting speed under following conditions.

(b) On Class 1 and Class 2 hoists, it is often advantageous for the operator to start the skip from the bottom and for the skip to make a round trip before the operator is again required to give it attention. Such a controller requires a push button for starting up, a push button for starting down (to be used only in cases of emergency or try-out), a stop switch, a time element relay for holding the motor at standstill for approximately five seconds at the top while the skip is being dumped, and limit switches for slowing down and stopping at each end of travel.

(c) On all classes of hoists it is sometimes advantageous to have a means of starting the skips into operation and having them run continuously without further attention, with approximately five-second intervals at each end of travel for loading and unloading. Such a controller would require a starting up push button, a starting down push button, a stop switch, necessary time element relays and limit switches for slowing down and stopping at each end of travel.

(d) Class 1 and Class 2 hoists sometimes require a five-second interval for unloading at the top, and an automatic switch connected with a scale beam for starting the skip at the bottom. Such a hoist will run continuously when once started and will automatically dump and reverse at the top, and will remain at the bottom on a scale beam until a pre-determined weight of material is spilled into it, whereupon it automatically is hoisted to the top. Such a controller requires a starting up push button, a starting down push button, a stop switch, time element relay, master switch operated by a scale beam, and the necessary limit switches for slowing down and stopping at the end of travel. It is also necessary that there be a certain amount of slack rope leading to the bottom skip when it first rests on the scale beam at the bottom of each shaft—one scale beam starts one of the skips up when loaded, and the other scale beam starts the other skip up. In addition to this, a time element relay might be inserted to hold the motor at standstill not only while the scale beam is operating, but for a predetermined time of about five seconds so as to make sure that the top skip has been fully emptied. Such a controller would require a starting up push button, a starting down push button, a stop switch, two master switches which are operated from scale beams, necessary time element relays if desired, and limit switches for slowing down and stopping at each end of travel.

A necessary part of all of the above control apparatus is that the motor be equipped with a solenoid brake; but under one special condition it is possible to operate a skip hoist without a solenoid brake, and this on a Class 1 hoist, although this is not always to be recommended on account of other disadvantages; for instance a brake of some kind may be needed when repairs are made. A series wound d.c. motor can be used for hoisting, and if the hoisting speed is such that the material is fully dumped at the time the skip reaches the top of travel, the motor can be allowed to reverse immediately and descend by dynamic braking, using a normally closed contactor. Stopping at the bottom can be obtained by decreasing the dynamic braking resistance and then allowing the skip to settle at very slow speed onto a positive foundation at the bottom. When shunt wound direct-current brakes are used, a centrifugal switch or some protective relays are needed to prevent the current regenerated by the motor from sustaining the brake in case power fails. A sustained brake would allow the motor to overspeed.

STRENGTH OF REFRACTORIES AT HIGH TEMPERATURES.

The arrangement for testing refractory materials within a furnace at high temperatures which E. Rengade and E. Desvignes described a few weeks ago in a paper presented to the Paris Academie ("Comptes Rendus," vol. 119, pages 134 to 137) is that of a machine for determining a Brinell hardness. Instead of the ball of Brinell, however, they use a cone of an angle of 90 deg., as introduced by Ludwick. The furnace is of the Rosenhain graphite ring type. The specimen is roughly made of cylindrical shape, about 30 mm. in diameter; the shape does not matter provided the top and bottom are plane. On the top rests the cone; it is mounted in a graphite ring so attached to a jointed rod that the rod can be withdrawn to take pyrometer observations, and can afterwards be lowered on to the specimen and loaded with a weight of 10 kg. This is done when the temperature inside the furnace has become constant; the load is then put on for about 10 minutes, after which the temperature is redetermined. The curves obtained with different materials, high or low in silica or alumina, are regular and much of the same type showing that a gradual softening sets in, at temperatures which in the cases mentioned ranged from 1,150 deg. up to 1,270 deg. C., and which increased as the temperature was raised to 1,500 deg. C. maximum.

Damascene Steel and It's Origin

This Steel Is Receiving the Attention of All Those Interested in Tool Steels—Experiments on This Steel, Interrupted by the War, Now to Be Resumed.

By COL. N. T. BELAIEW, C. B.*

PART II

IN THE first paper on damascene steel[1], presented to the Institute in 1918 by the author, he described the general properties and structure of damascene steel, and pointed out the great claims it had to the attention of all interested in tool steel. The object of the present paper is to substantiate that statement, more especially as regards high-speed steels. In the author's opinion a marked analogy exists in the structure and in some of the properties of high-speed and damascene steels, and a comparative study of both might therefore prove beneficial in explaining certain properties and in opening new vistas.

2. Damascene steel belongs to the hypereutectoid series of carbon steels. As mentioned in the author's previous paper, the average carbon content of typical damascene articles should be about 1.5 per cent. That amount of carbon, however, does not exist as such, but as a definite chemical compound, Fe_3C, or cementite. Introducing the respective weights of iron and carbon:

$$(3 \times 56) \text{ iron} + 12 \text{ carbon} = 180\ Fe_3C,$$

we arrive at the result, that one part of carbon produces $\frac{180}{12}$ or 15 parts of cementite. 1.5 per cent of carbon in steel represents, therefore, 22.5 per cent. of cementite, which, from the practical point of view, is a very large amount. About one-half of this amount (11.5 per cent) forms the excess, or free cementite. The other 11 per cent of cementite with a corresponding amount of ferrite is used up in building up "pearlite."

The free cementite is coarser than the eutectoid cementite, its spreoidisation is correspondingly more difficult and necessitates repeated hammering and heating. The greatest care must be taken to break the large cementite needles into smaller particles and afterwards to cause their complete spheroidisation.

The Indian damascene blades, examined in Petrograd by the author, showed a perfect balling up, as may be seen froms Figs. 3 and 4 (Plates XLII and XLIII) of his previous paper. The completeness of the spheroidising process may be further illustrated by Fig. 1 (Plate XLI), which shows at a magnification of 1000 a section of an Indian blade, photogaphed in the author's London laboratory by Captain B. Brandt. The larger particles shown in the section are those of "free" cementite, the smaller ones are eutectoid cementites. Both groups are thoroughly spheroidised.

Figs. 1 and 2 (Plates XLI and XLII) of the author's first paper also show what a large amount of mechanical treatment (as shown by the macrostructure of the blade) was required to attain such complete spheroidisation. The macrostructure shows also that the cementite veins run closed up to the edge, and that therefore the oriental maker must have relied most upon securing the best cutting properties of the cementite particles.

3. High-speed steel is a tool steel which possesses the property of maintaining its hardness at a relatively high temperature. This property is secured in a large degree by adding tungsten and chromium, usually 16 to 20 per cent of the former and from 3 to 5 per cent of the latter; the carbon content is generally not over 0.75 per cent; up to 1 per cent of vanadium is also added.

This steel belongs to the cementitic (carbide) series; its structure (Fig 1, Plate I), when annealed, presents a striking similarity to the structure of damascene steel (see, for instance, Fig. 336, p. 356, of Sauveur's "Metallography"). Spheroidised carbide particles are embedded into a sorbitic matrix. To produce "high-speed hardness" such steel has to be heated to a very high temperature, and then quickly cooled. A certain amount of carbide remains undissolved, even after rapid cooling from temperatures close to the melting point (see, for instance, Figs. 334 and 342 (Yatsevitch) of Sauveur's "Metallography"). There are even indications that a moderate amount of free carbide appears to increase the cutting properties of the tool.

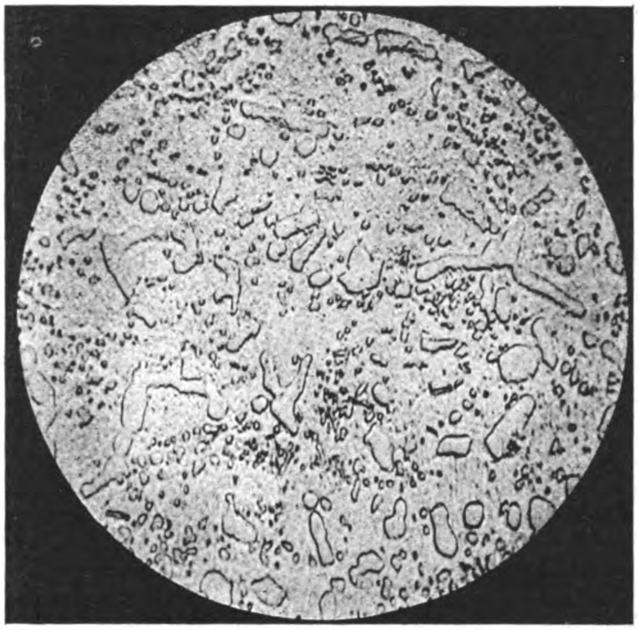

Fig. 1—An Indian blade from the author's collection. Globules of spherodized cementite embedded in a sorbitic matrix ×1000.

The actual makers of high-speed steel, however, em-

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*Paper presented before the British Iron and Steel Institute, September 5-6, 1921.

[1] Colonel Belaiew, "Damascene Steel," *Journal of the Iron and Steel Institute,* 1918, No. I, p. 417.

[2] "The Manufacture of High-Speed Steel in the Electric Furnace," by Rog. C. McKenna, President of the Vanadium-Alloy Steel Corporation. *Transactions of the American Electrochemical Society,* vol. xxxvii, p. 322.

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phasize that the making of the high-speed structure begins under the hammer; that during this operation "the massive carbides and tungstides present in the ingot are broken down and uniformly distributed throughout the billet;'" and further, that "to accomplish this the reduction in area must be sufficient." Therefore, ingots are first hammered into billets, the billets are again slowly heated and then hammered for a second time ("cogged")—all this "mechanical treatment" by properly breaking and evenly distributing the carbides (and tungstides) throughout the steel.

4. If we proceed now to compare not only the photomicrographs, but also the two processes—the "high-speed hardness" and the "damascene" process, we see how similar they are.

Both start with a cementitic steel; both require the greatest care in breaking and evenly distributing the carbides under the hammer; in both cases the amount of mechanical work spent on a given article is very large, but however large it is considered indispensable before a suitable heat treatment may be effected. In both cases the structure of carbides is spherolitic, whilst the matrix, after the heat treatment, is martensitic. In both cases also the cutting properties of the edge are related not only to the matrix, but to the carbides as well. The author is even inclined to think that the properties and the distribution of the carbides play a more considerable rol ethan the matrix. On this ground may be explained the reason why, on the one hand,, such diversities of opinion exist as to the structure of the matrix in high-speed steels, whilst, on the other, neither the old eastern makers nor Anossow seemed to attach any real importance to the tempering of damascene steel. The author's studies in this field have led him to the belief that whilst being very strict as regards the hammering temperatures, nobody who has really busied himself with damascene steel cared much as to its subsequent heat treatments.

5. There are a few conclusions which can be drawn from these preliminary remarks:

First, there is the question of spheroidisation of the carbides. In damascene steel the degree of spheroidisation is always very high. That spheroidisation, however, was not an end in itself for the ancient maker, but was attained, so to say, incidentally during the numerous cautious forgings and heatings, when the greatest ductility was sought and obtained.

In high-speed steels that spheroidisation is also attained, but it seems to the author that insufficient stress has been laid on that point, either by the high-speed steel maker, or user. He believes that a scientific application of the spheroidising process would help to improve the qualities of high-speed steel. He thinks, further, that another inference from the damascene process might be drawn, namely, the proper study of the macrostructure. An oriental maker would never manufacture a steel article without having satisfied himself, by studying the watering, that the distribution of the carbides is the best possible and quite in accordance with the shape and properties of the article. Neither would he find a buyer ready to accept a sword or tool without a proper "metallographic" examination of it as a whole (towards that end the splendid oriental watering lent itself so well). The author therefore believes that a proper examination of the "watering" of high-speed steel, either in billets or in the finished article, will prove useful.

As to the damascene steels, whilst not ready to place them in the category of high-speed steels, the author is, however, inclined to think that a certain "high-speed harness" which he noticed during his experiments on damascene steel (interrupted by the war) might not prove quite accidental, but useful for further investigation.

TORONTO PLANT NOW COMPLETED.

The Toronto plant of the Follansbee Brothers Sheet and Tin Plate Company which is now almost ready for operation, stands unchallenged the last word in the steel industry; the colest, best equipped and most convenient and systematically arranged plant of its kind in the world.

Cost About $5,000,000.

Stretching for a quarter of a mile along the river, the new plant gives a splendid impression. The big plant is modern in every respect and with its great power plant with three stacks each towering 175 feet in height, and with all shops and other separate buildings of light brick, the mill gives to the outsider an impression of progressiveness on the part of the operators.

Open Coal Mines.

When the company started building its new plant the securing of fuel and electric current was considered an outside matter. With coal lands in the vicinity and a great power company operating in the district it was not then indicated that the company would be independent of such services. However in the past year and a half a coal mine has been developed and a power plant second to none in the state of Ohio erected on the river's edge.

Coal is then automatically brought to the entrance of the mill where it is in turn powdered. It is then used for feeding eight Hughes automatic gas producers. Each producer consumes four tons of coal per hour.

The Power House.

The gigantic power house has a capacity of 7,500 kw. There are three batteries of two boilers each having 3,600 hp. All boilers are equipped with Westinghouse stokers, forced draft soot blowers and automatic skip hoists for ashes and soot.

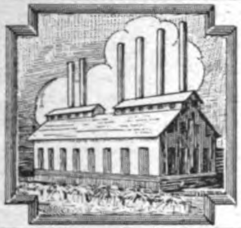
Open Hearth.

Modern open hearths have been built in addition to the complete bar mill practically equipped. The bar mill is similar to the one which the Company now operates at Follansbee. There are ten hot mills. The sheet mills are larger than those at Follansbee. Four being 50", three 44" and three 40".

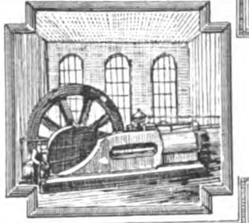
New Annealing Process.

Among the features of the Toronto plant is the annealing equipment. There are two big Dressler kilns working a continuous process of annealing. One kiln is 350 feet in length and the other 320 feet. This represents the most modern annealing plant known to the steel world. In addition to this equipment there is a carpenter shop, store room, and other essential buildings.

When completed and working in full capacity, the plant will employ about one thousand workmen. It is the intention of the company to start operations about October 1st.



STEAM POWER DEPARTMENT



Boiler Water Treatment Plants

The Various Methods in Use for Treating Bad Water—This Is Accomplished by Chemical Means, Mechanical Means or by Thermal Treatment.

By ROBERT JUNE, M. E.

PART II

IN OUR preceding article we dealt with the nature of the various impurities in boiler feed water, and the operating troubles resulting from them. We have now to consider the various methods in use of treating bad water.

According to our previous outline, the neutralization or elimination of impurities in feed water may be effected by one or more of the following methods:

I—By chemical means.
    (a) Boiler compounds.
    (b) Water softening plants.
II—By mechanical means.
    (a) Tube cleaners.
    (b) Blow off.
    (c) Filter plants.
III—By thermal treatment.
    (a) Feed water heaters.
    (b) Distillation plants.

Boiler Compounds.

There are a number of boiler compounds in use, but the base of most of these is carbonate of soda, to which caustic soda is sometimes added and occasionally phosphate of soda. In addition materials containing tannin and starch are frequently added, with the object of coating the particles of precipitated matter so as to prevent their corrosion.

The use of boiler compounds is sometimes condemned as thoroughly bad practice, the following contentions being made: That mechanical difficulties prevent the maintenance of a proper ratio between the amount of compound used and the volume of water; that it is very difficult to control the treatment to take care of the changing analysis of the water; that adequate boiler compound treatment is very expensive; that compounds necessitate frequently blowing down the boiler to prevent an accumulation of sludge and sodium salts, which cause foaming, and that, moreover, blowing down must frequently be supplemented by washing out and occasionally cutting out the boiler completely to remove foreign matter.

Despite these criticisms, boiler compounds still find favor with many practical men, particularly in small boiler plants. When it comes to compounds, a great deal of care and attention must be paid to their selection and use. A great deal depends upon the attitude of the compound manufacturer. If he is willing to sit down and thresh out your problem with you, you may receive satisfactory service at a cost that is not prohibitive.

It is all simply a matter of relation of costs to the results obtained. While there are some compounds on the market which are worthless, and some manufacturers who offer cure-alls and do not give satisfactory service, there are other compounds which are reasonably satisfactory and do not involve a large plant investment. Though the weight of evidence is very much against the indiscriminate use of compounds, the fact remains that they are in satisfactory use in many small plants.

Graphite.

Graphite has no retarding influence on the formation of scale, but it tends to prevent the scale from adhering firmly to the metal. The particles of graphite simply work through the minute fissures existing in the old scale and gradually penetrate between the scale and the metal. The scale thus loosened may be knocked off or removed with regular cleaning tools with little trouble.

Before starting the use of graphite, the boiler must first be thoroughly turbined. Once removed, the scale will not adhere firmly to the metal again as long as the gaphite treatment is continued. The graphite also becomes intermixed with new scale as it forms, rendering it soft and friable. With graphite, as with boiler compounds, any boiler using bad water should be blown down a gauge or two every few hours to remove sludge.

Kerosene.

Good results in softening scale are sometimes secured through the use of kerosene and other refined petroleum oils. This treatment changes the deposits of lime from a hard scale to a friable material which may be easily removed. If the treatment is to be effective, kerosene should be introduced after the boiler is emptied and washed, and the refilling should be effected from the bottom. If kerosene is fed into the boiler with the feed it may form a non-conducting film over the heating surface.

Zinc.

While zinc is often introduced into boilers to prevent corrosion and scale formation, it does not as a matter of fact always accomplish this purpose, and it may even aggravate the trouble. The action of zinc is electrolytic, the theory being that a continuous flow of hydrogen is generated over the whole extent of the wet surface of the boiler. It is supposed that the continuous formation of the bubbles of hydrogen insulates the surface of the metal from the scale forming substances. If there is a little of the scale forming element it is precipitated and reduced to mud; if there is considerable, a formed scale is produced which, however, does not adhere tightly to the surface of the metal and is consequently readily removed.

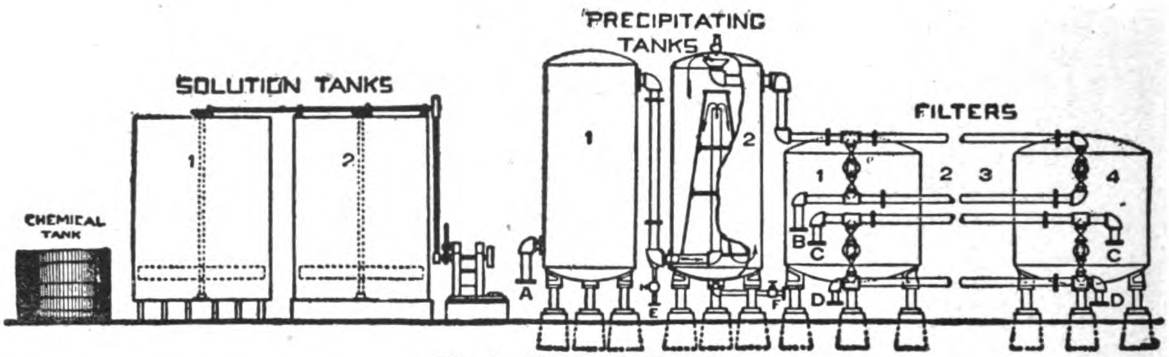


Fig. 1—The Scaife System.

The zinc is introduced in the boiler where it is suspended in the water in the shape of blocks, slabs or shavings, in a perforated container. In marine practice, where zinc is in much greater use than in stationary boilers, it is usual to find zinc slabs 12"x6"x1½" in use. One square inch of zinc surface is ordinarily supposed to be sufficient for 50 lbs. of water in the boiler, although as a matter of fact the quantity of zinc used should be in proportion to the hardness of the water. The British admiralty, who are advocates of zinc, recommend renewing of the slabs when their disintegration reaches a depth of ¼".

Boiler Metal Treatment.

A treatment which has in recent years come into quite wide use consists in the application of Perolin. This is a blue viscous non-volatile mineral liquid, which possesses the characteristic of an exceedingly high coefficient of expansion. The liquid is injected into the boiler in small daily doses. It penetrates the pores and crevices in the scale and comes into direct contact with the metal, where, like graphite, it works its way along the steel, eventually forming an insulating coating between the scale and the tubes. The high coefficient of expansion tends, whenever the boiler is cut in, to loosen any scale which has formed.

Advantages and Disadvantages of Compounds and Metal Treatment.

Compounds and metal treatment of the various sorts described above possess the advantage of not requiring an initial plant investment and of lending themselves very readily to experimentation. In case a given compound or treatment does not work, it may be modified, or another treatment may be tried. The operating costs are also less per gallon of water treated than where special treatment is installed.

The serious disadvantages of compounds and metal treatment are that under favorable conditions all that the most effective of these methods can do is to change the nature of the scale forming materal from one which will be precipitated to one which will be carried in suspension. Frequent blowing off is at all times necessary with consequent heat losses, and as the accumulation of sludge can never be entirely removed while blowing off, so that the boiler is frequently cut in for washing. This puts the boiler out of commission and entails a loss on the investment in the boiler whenever an extra steam generator must be provided to take the place of those cut out for washing. Frequent cutting in and out of the boiler itself is an expensive operation. Taking everything into consideration, compounds and metal treatment are to be recommended for use primarily in small plants. In large plants, and in particular where steam must be continuously generated, we must turn to a method of treating the water before it enters the boiler.

Water Softening and Purifying Plants.

The treatment of water outside of the boiler through the medium of water softening plants is accomplished by either one of two processes, known as the intermittent and the continuous.

Cold process plants are used primarily where water is required in very large quantities. Hot process plants are commonly used where exhaust steam is available for heating the water.

With the continuous system, the water to be treated flows to the softener in a continuous stream, while with the intermittent system it is treated in batches. Successful treatment in either case requires the proper proportioning of water and chemicals, thorough mixing and agitation, and the allowance of sufficient time for the reaction to take place so that all of the sludge may be removed from the water.

Lime and soda are the principal ingredients used in these processes, where sulphates of lime and magnesia are contained in the water, together with such quantities of carbonic acid or bicarbonate present as to impair the action of the soda. This is quite a common condition. The sulphates of lime and magnesia are broken down by the soda, and as much lime is added as is required to take up the carbonic acid not absorbed in the soda reaction.

Before dealing with the apparatus, it may be well to describe simply the chemical tests of the treated water which will enable us to interpret intelligently the results being obtained. Alkalinity, hardness and causticity, should, when the water is properly treated, be in the approximate relation of six, five and four. The use of too much lime will result in causticity being nearly equal to alkalinity. The use of too little lime will result in a causticity amounting to only about half the alkalinity. If too much soda is used, hardness, which should not be more than two points less than alkalinity, will be decreased below this amount, and the alkalinity correspondingly increased. Too little soda means an increase in hardness and a decrease in alkalinity. The tests are as follows:

Alkalinity—Provide a standard solution of sulphuric acid. Put sufficient methyl orange in 50 cc. of the water being tested to color it. Measure out a quantity of the acid solution and put it in a drop at a time. As the acid solution is added the mixture will begin to turn red. Shake the mixture and the redness will tend to disappear. Put in more acid and continue to shake. As the critical point is approached the red will disappear more slowly. 1/10 cc. of the acid solution is equivalent to one degree of alkalinity.

Causticity—Use the same standard solution of sulphuric acid. To 50 cc. of the treated water add one drop of phenolphthalein dissolved in alcohol. This is to give the water a pinkish color. Put in a drop at a time of the acid solution, shaking after each addition. The critical point is reached when the color entirely disappears. 1/10 cc. of acid solution is equivalent to one degree of causticity.

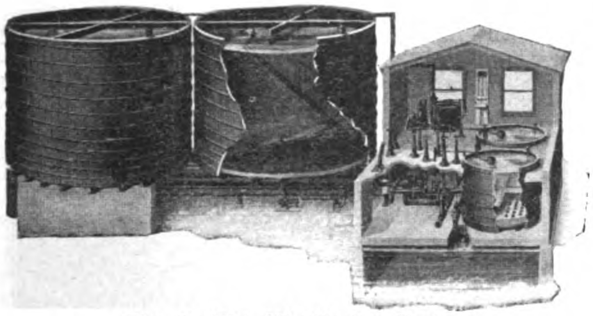


Fig. 2—The We-Fu-Go System.

Hardness—Procure a standard soap solution. To 100 cc. of the water to be treated, add 1 cc. of the soap solution, and shake thoroughly. If the soap bubbles disappear, add another cc. of the soap solufion. Enough of the soap solution must be added to make a permanent lather or foam from which the soap bubbles will not disappear after the shaking is discontinued.

To determine the excess of lime, add a small amount of silver nitrate to the treated water. If a milky white solution is formed the lime is not in excess. If the mixture turns brown there is too much lime

The Scaife System.

In the Scaife system, which is a continuous one, the feed water first enters the heater, where it is brought to a temperature of 200 to 210 deg. F. As a portion of the CO_2 is driven off by the heat, carbonates of lime and magnesium are precipitated and deposited in removable pans inside the heater.

The system consists of a number of precipitating tanks with one or more pressure filters, all built to operate under the boiler pressure, and the necessary solution tanks, pumps and controlling devices. The precipitating tanks may be either horizontal or vertical, depending upon the space available. The solution tanks hold sufficient quantity of chemicals to operate the plant from eight to twelve hours. The small pumps deliver this solution to the precipitating tanks, which are so constructed that the water is kept constantly moving and the chemicals are intimately and thoroughly mixed. In this manner acids are neutralized and the scale forming substances are changed to insolubles which sink in the form of heavy precipitates to the bottom of the tank, whence they are readily removed. From the precipitating tanks the mixture moves to the filters, where the lighter substances in suspension are effectively removed.

We-Fu-Go System.

The We-Fu-Go is an intermittent process. The system consists essentially of one or more solution tanks from which the chemicals are taken, and one or more settling tanks into which the water to be treated and the chemicals are introduced, and of one or more filters. A thorough mixture of the chemicals and the water in the settling tanks is effected by the use of mechanically operated paddles located near the bottom of the tank. The softened water is taken out of the tank by means of a hinged floating outlet pipe, arranged to rise and fall with the level of the water, so that the water is always drawn from the top, where there is the least amount of sludge. From the settling tanks the water flows by gravity into the filters, which remove all remaining solid matter which has not dropped to the bottom of the settling tank.

From the filter the purified water again flows by gravity into the clear water storage reservoir from which it is pumped to the open heater and thence to the boiler. As a general rule duplicate systems are employed, so that while one tank is being treated and settled, the other is supplying finished water.

It should be understood, of course, that the above descriptions of the Scaife and We-Fu-Go systems are general in nature, as modifications of both of these systems are often made to meet special conditions.

Our next article will deal with the operation and maintenance of the water softening plants described in this article and we will also take up in detail the design, construction and operation of Zeolite plants.

DEVELOPMENT IN INDUSTRIAL EDUCATION.

Although hundreds of industries have experimented with various plans for training their employes, it has remained for the Pennsylvania State College to work out a plan which appears nearer to the ideal than anything yet attempted. The methods adopted by this institution have long since passed the experimental stage and are in operation in a large number of plants in Pennsylvania where it has been demonstrated that an efficiency far beyond that of ordinary class instruction can be obtained.

For ten years a staff of highly trained men in industrial education has been maintained at State College, and large sums of money have been spent in studying methods of conducting apprentice schools and night classes in the industries. This staff, known as the Engineering Extension Division of the College, has personally organized and operated hundreds of classes in some of the best known plants in Pennsylvania, among them being manufacturers of iron and steel, electrical equipment, machines and tools, automobile parts, textiles, and others common to the State. Each such enterprise was accompanied by an intensive study as to the characteristics which entered into its success or failure. The natural result has been that improved methods were continually adopted until it can now be practically assured that a company can inaugurate a general training policy with far more success than is generally believed possible.

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PRODUCTION TOPICS

OUTLINE OF A PRACTICAL COURSE IN STEEL-MAKING.

By P. S. Young

In every plant producing steel products there is present a number of employes which, when properly trained and experienced, will become rare executives in their departments. Also, having had practically no experience in other departments of the mill, most of these men will be narrow in their views of other departments of the plant. Now, in spite of this the time will come when these men are in line for promotion to a higher executive position, and the position will have to accept them just as they will have to accept the position. The longer their work has lain in one department, the harder it will be to adjust them to the higher position requiring them, and the more the position will shrink to fit them.

Such being the case, if a selection from this latent ability were to be made, and the selected men thoroughly coached in the various departments, each when placed in a department would have a broader scope of the needs of the other branches of the mill, realizing the relationships of the other departments to their own, what they bless and what they curse, step by step in the unfinished products.

They are far more fit for departmental control and better equipped to handle a number of departments. No friendships or executive meetings among the department heads breaks down the loyalty of a man for his department or his prejudices established on his own troubles. One must have worked in a blast furnace plant to appreciate "cold cores" in an open hearth to understand the trouble with a bad "sticker," in a blooming mill to find sympathy for "green" steel or "washed," in a rod mill to understand "cross-rolled" and "finned" product, or in an electrical department to sympathize with an industrious craneman whose crane has controllor trouble or burns up an armature at the busiest moment.

Now say that this latent ability could be selected at an early stage of its career, and others could be brought into the mill fresh from some good technical school, would these men develop with proper training into the class of ability required? There can be but one answer, which is "yes" provided:

First—The selection is careful, combining good technical education with willingness and ability to work.

Second—The training is actual work and experience covering the essential details of each department.

Third—Proper supervision by the then department head.

Fourth—A contract between the student and the company that he will be taken care of until placed, if he finishes his course successfully; and that he, the student, will give the company a certain period to be agreed upon at the time of taking up the course for them to place him.

Item 1. Careful selection.

a. Technical education with good grades in chemistry, physics and higher mathematics.

b. Graduated at least one year. This is to take away any chance of his following theoretical instead of practical phases of the work on the course.

c. A thorough physical examination to show if the man is fit and sturdy enough for the work which he will have to do.

d. If brought in from outside the plant, one month of work at labor in various parts of the plant to see how easily he is disheartened, and with a written report at the end of that time describing the jobs he has been covering. This report should show his ability in reconstructing difficulties under which he has worked, any better way he could show of doing the work, and testing his memory.

N. B.—During this month the applicants may be kept in a gang or worked singly at labor rate, the first two days for six hours, the next two for seven hours, until they are working ten hours daily. If in a gang, they may sometimes be put in an awkward formation to pass brick, or to unload a car, to see how quickly they grasp the fundamentals of gang labor.

e. At the end of this time another physical examination should be made to determine how they have been affected by the work.

f. The pay for the whole course should be extremely low, but should be raised a few dollars at the end of each six months. Even with low pay and no advertising, there will be no lack of material. In fact, you will be surprised at the amount of elimination necessary, and the man who is willing to take this two and a half year course at a bare living wage is more in earnest about his future than another man would be.

g. Two is the proper number to enter one class of the course. There should not be more than four, and with two there is a strong spirit of competition. It is also friendly competition which only two can have. If three or four are in the same class, there is always one who may be the equal or better of the others, but who finds himself standing alone and does not get the coöperation of the others in the class. It is also easier to handle the work of two than of a greater number.

The students are now selected and the course proper begins.

Items 2 and 3. Training in actual work under the proper supervision.

The men should start at the lowest jobs in each department and work at each job for a sufficient time to learn the details of the work. They should do the actual work taking notes of all intricacies of the work. They should work part of the time (a small part) on night turn. They should be in the department office for one hour each morning, undisturbed, in which time they should study text books on their work and make permanent record of their notes of the day before. At unexpected times the department superintendent or assistant superintendent should give them written examinations on the parts of their work covered to date. Their study should be together, but their examinations should be written by them without aid of each other. They should see their papers and marks.

At the end of their courses in each department, they should write long theses of their course describing machines, phases of manufacture, difficulties in operation, both mechanical and chemical, and a general survey of their work. It has been found better in some plants to have the two men work together on these papers, though they should be different enough to show individual thought. No extracts from text books should be used in compiling these papers, as the idea is for the student to get the whole working for himself.

(Continued in November issue.)

WITH THE EQUIPMENT MANUFACTURERS

NEW TYPE OF BELT DRIVEN AIR COMPRESSORS

The Ingersoll-Rand Company, 11 Broadway, New York, has announced a new line of belt driven air compressors. This type is known as the "Imperial" Type "XCB" and has incorporated in it several noteworthy features of construction, including Ingersoll-Rand plate valves, for both the air intake and discharge, and the 5-step Clearance Control for regulating the compressor's output.

The plate valves used in this type of compressor have been perfected after a most complete analysis of the light-weight plate type of valve. They include the features which have been proven necessary to the successful functioning of this type of valve, the most important of these being, that the valve is supported throughout its entire operation in perfect alignment without any form of wearing guide—a very essential feature in the life of the valve.

The Clearance Control has been used with great success on the larger direct-connected electric motor driven compressors manufactured by the same Company and has proven itself to be the most satisfactory and efficient form of compressor regulation. Thousands of these direct-connected air compressors are installed in all parts of the world and are well-known by those in charge of plants where conditions call for more than 600 cubic feet of free air per minute and where direct-connected electric motor drive is used. The use of this form of regulation is a most noteworthy development in air compressor design during recent years and should be of interest to all users of air power.

The Clearance Control is a method of securing extremely efficient operation at partial loads. Under average working conditions it is a well-known fact that the demand for air is seldom steady throughout the working day and for this reason the performance of the compressor at underload is of primary importance.

With the Clearance Control the compressor is automatically loaded or unloaded in five successive steps, these steps being obtained by the reduction or addition of Clearance space to the air cylinders. The compressor will operate at full, ¾, ½, ¼ and no loads and the design of the Clearance Control is such as to secure efficient operation at any one step the reduction in input power required being practically in proportion to the reduction in output capacity.

The entire Control is automatic. If the compressor is operating at full load and the demand for air falls off this Control automatically causes the compressor to operate at one of the underload points such as ¾, ½, ¼, or no load. When the demand for air is increased the compressor automatically assumes the load in successive steps.

An extremely valuable feature of the Clearance Control is the fact that the Clearance Pockets are made integral parts of the compressor cylinder and the entire regulation is obtained by the control of the volume of air taken in and compressed.

With this method of control there is no loss of power due to wastage of air and leakage. The Clearance Pockets in the cylinder are automatically thrown in communication with the ends of each cylinder in proper succession, the process being controlled by a predetermined variation in receiver pressure. With the compressor operating at partial capacity a portion of the air is compressed into an added clearance space instead of passing through the discharge valves. On the return stroke this air expands giving up its stored energy to the pistons.

The inlet valves remain closed until the cylinder pressure equals the intake pressure. At this point the inlet valves are opened automatically and free air is taken into the cylinder for the remainder of the return stroke. Thus the inlet capacity is reduced without reducing the intake pressure. On a two-stage compressor clearance space in proper proportion is added simultaneously for both high and low cylinders giving a constant ratio of compression and maintaining conditions necessary for the highest compression efficiency throughout the entire load range.

Another added fature of this control is the maximum demand stop which will prevent the compressor being operated at any higher maximum load than is desired. This can be adjusted so that the compressor will operate on a maximum of ¼, ½, ¾, or full load and, under conditions where the load factor is comparatively low, it is of value in reducing the maximum demand, permitting a saving in the purchase of electric power—a feature found in no other type of control.

With the Clearance Control reduction in power required will be in proportion to reduction in output capacity. All the mechanism for regulating the compressor is independent. of the compressor running gear. The loading and unloading of the compressor is automatically accomplished in steps, the difference between any two steps being small enough to prevent any undue electric current fluctuation .

It will be seen that all of these features are of extreme importance the combination producing conditions requisite for the most efficient opration at full and partial loads.

This new type of belt driven compressor equipped with Clearance Control can be furnished single-stage for low pressures and two-stage for higher discharge pressure. The piston displacement capacity for 100 pounds discharge pressure ranges from 610 to 1505 cubic feet of free air per minute.

QUICK MAKE AND BREAK SAFETY STARTING SWITCHES

To withstand the most severe service in industrial plants, the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., is manufacturing a switch of very rugged construction with quick make and quick break action.

The quick make and quick break mechanism which operates the switch blade is enclosed in an external cast-iron hub or housing integral with the operating handle. This complete mechanism can be removed and replaced without disturbing the enclosed switch.

Over the fuse compartment is provided a door. The door is so interlocked that it can be opened only when the switch is in the "off" position, at which time all accessible current carrying parts are dead. This door may also be locked so that only authorized persons have access to the fuses. An outer door provided with means for sealing or padlocking opens over the whole front of the switch cabinet, making it possible to inspect the switch while in operation or to make motor-load test connections without stopping the motor. A three-hole bracket on the side of the cabinet permits the switch to be locked independently by three individuals.

NEWS OF THE PLANTS

The Norton Iron Works, Ashland, Ky., is completing plans for the erection of a new two-story plant addition, 150x200 feet, steel and reinforced concrete, to be equipped for general production. Construction will be commenced at an early date; it is estmiated to cost close to $50,000.

The Delaney Forge & Iron Corporation, 300 Perry street, Buffalo, N. Y., is planning for the early rebuilding of the portion of its plant destroyed by fire, August 29, with loss estimated at close to $250,000, including buildings and equipment. The structures destroyed include a number of shops and power plant.

The John Swane Arch Iron Works, Inc., Cypress street, Springfield, Mass., has awarded a building contract to A. M. Kramer, Springfield, for a new shop addition for increased production. The structure will be one and two-story, 32x66 feet, and equipped for general iron working. Construction will be commenced at once.

The Follansbee Brothers Company, Pittsburgh, Pa., is planning to inaugurate operations at its new plant at Toronto, Ont., now in course of construction, early in October. Erection work is being rushed to completion and double crews of workmen are being employed for machinery and equipment installation. The new plant will be run in conjunction with the other works of the company.

The Wyckoff Drawn Steel Company, Frick Building, Pittsburgh, Pa., has plans under way for the early erection of a new plant at Wyckoff, near Ambridge, Pa.; the structure will be one-story, about 60x250 feet and estimated to cost close to $75,000. William C. Undercoffler is engineer for the company.

The Lehigh Structural Steel Company, Allentown, Pa., has preliminary plans under way for the erection of additions to its plant for increased production. It is proposed to construct a number of works buildings for general production as well as other iron-working, including repair service.

The Vulcan Iron Works, Hudson and Essex streets, Jersey City, N. J., operating a marine engineering works, is planning for the rebuilding of a portion of its plant recently destroyed by fire, with loss estimated at about $250,000, including machinery and equipment. Six structures at the works were destroyed. Arthur J. Grymes is president.

The International Steel Tie Company, 16702 Waterloo road, Cleveland, Ohio, is planning for the erection of a new plant on Waterloo road, for the manufacture of steel ties for railroad service and other steel products. The structure will be one-story, 40x120 feet, and is estimated to cost about $45,000. W. C. Mahon is secretary.

After a considerable period of inactivity, a number of steel and iron plants at Buffalo, N. Y., are resuming production, with indications of early resumption of close to normal manufacture. The Lackawanna Steel Company has added a large number of employes to its working force, including a number of former workmen, and is now operating nine of its rolling mills. The company recently has arranged plans for the direct sale of pig iron, and is said to have secured orders for close to 50,000 tons for early delivery. The Wickwire Steel Company has placed a number of additional mills in service, with increased working force. The Seneca Iron & Steel Company, with plant at Blasdell, near Buffalo, is again in operation, after a shut-down of a number of months. The limestone plant of the Wickwire Limestone Company, a subsidiary of the Wickwire Steel Company, located at Lockport, N. Y., is in operation; the power house at this plant was recently destroyed by fire, with loss estimated at close to $30,000, and will be rebuilt at an early date.

The Hercules Steel Post Company, care of G. J. Pammel, secretary of the Chamber of Commerce, Niles, Mich., local representative, has plans nearing completion for the erection of a new steel plant on local site for the manufacture of steel products. It will be one-story, 50x250 feet, and is estimated to cost close to $40,000.

The American Manganese Steel Company, New Castle, Del., is planning for the rebuilding of a portion of its local plant, destroyed by fire recently, with loss estimated in excess of $200,000, including machinery and equipment.

The Illinois Steel Company is now giving employment to about 800 men at its Bay View mills, Milwaukee, Wis., and operations are being increased at the works. The working force is now about 65 per cent of normal. Four rolling mills and a number of subsidiary works buildings are in service.

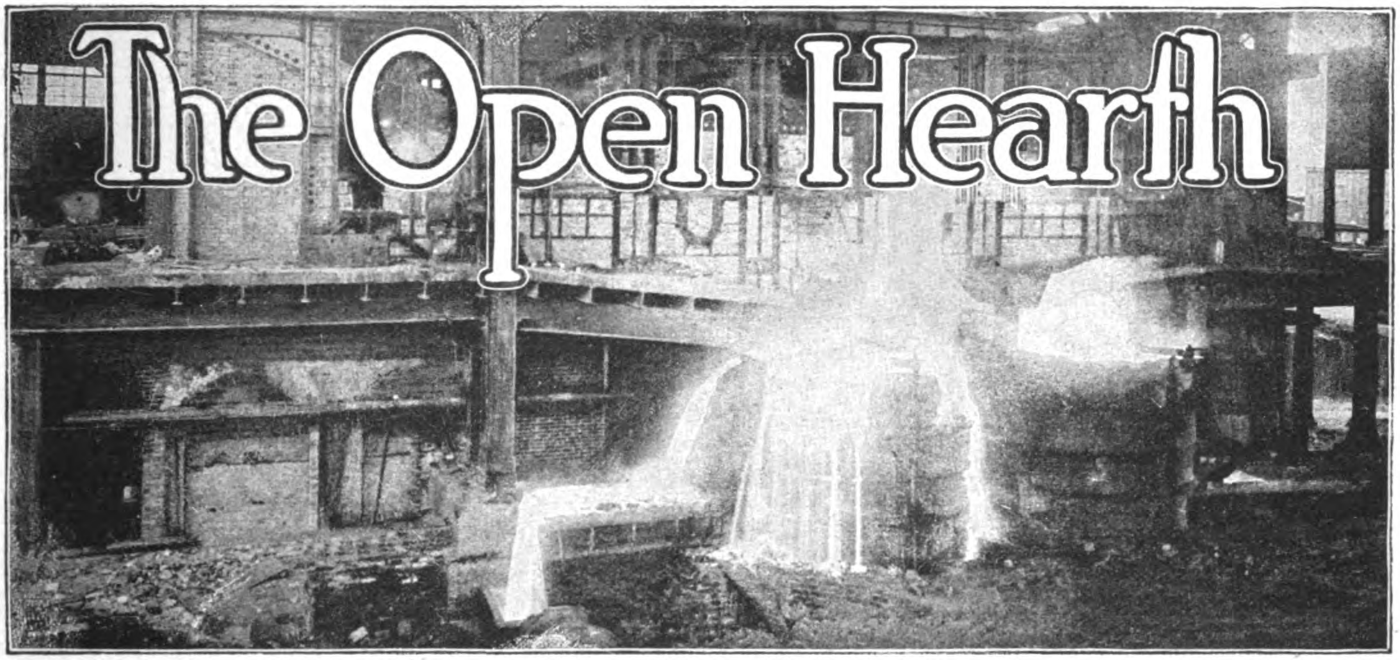
The Union Steel Castings Company, Sixty-second and Butler streets, Pittsburgh, Pa., has commenced the erection of a new one-story plant addition for increased production.

The United Engineering & Foundry Company, Pittsburgh, Pa., is maintaining active operation at its steel works and rolling mills at Youngstown, Ohio. The company has been making large shipments, aggregating close to 10,000 tons of material, to England, France and other foreign points. It is said that orders on hand insure production for some months to come.

The E. P. Bailey Steel Company, Nitro, W. Va., has commenced the construction of a new local plant, comprising a main one-story building, 75x400 feet, with a number of smaller structures, estimated to cost in excess of $135,000, including machinery and equipment.

The Trumbull Steel Company, Warren, Ohio, has preliminary plans under consideration for a new byproduct coke works at its mills in the vicinity of Youngstown, Ohio. The company has recently completed the construction of a new 600-ton blast furnace at this location and plans to blow the unit in during the fall. The furnace will be utilized for the supply of iron to the company's open-hearth furnaces across the Mahoning river.

The A. M. Byers Company, Pittsburgh, Pa., has improvement work under way at its Mattie blast furnace at Girard, Ohio. The work will comprise general over-hauling, repairing and certain remodeling, preparatory to placing the unit in service. It is said that the plant will be blown in during the fall. The company is operating 22 puddle furnaces at its No. 1 mill at this plant, and one of its bar mills.



The Open Hearth

George P. Hansen has been appointed superintendent of blast furnaces for the American Rolling Mill Co. at Columbus, Ohio. Mr. Hansen was formerly in charge of blast furnaces for the Republic Iron & Steel Company, Youngstown, Ohio.

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J. C. Ward of Sheffield, England, is in the United States on business. Mr. Ward is president of the Edgar Allen Steel Co., Inc., Chicago, and is also managing director of Edgar Allen & Co., which operates the Imperial Steel Works at Sheffield.

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Norman Allderdice recently became sales manager for the Pittsburgh and Cleveland districts of Manning, Maxwell & Moore, Inc., succeeding Robert A. Bole, who died about four months ago. Mr. Allderdice was formerly in charge of the open-hearth department of the Lorain, Ohio, plant of the National Tube Company, and under his management the open-hearth department made a splendid record. He carries with him to his new position a knowledge of steel plant machinery and equipment. He is the son of Taylor Allderdice, vice-president National Tube Company. His headquarters will be maintained at 1005 Park Building, Pittsburgh, Pa.

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W. C. Dennis, Birmingham, Ala., after completing a three-year contract in the general construction of a large steel works at Jamshedpur, India, has returned to that city. Templeton Tutwiler, Birmingham, is general manager of the works. The Tata Iron & Steel Co. owns the plant.

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Chairman Elbert H. Gary of the United States Steel Corporation left September 7 for Mexico. It is understood that the journey will not be in connection with business purposes. Judge Gary is expected to be back in New York in about four or five weeks.

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F. W. Gray was recently appointed assistant to D. H. McDougall, vice president of the British Empire Steel Corporation. Mr. Gray was formerly editor of the Canadian Mining Journal. Mr. Gray went from England to Canada in 1904 in the service of the Dominion Coal Company, remaining with it as confidential assistant to several general managers, and was afterwards assistant to the president of the Nova Scotia Steel & Coal Company for a year.

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J. A. Durfee, since March 1st, 1920, works manager of the Page Steel & Wire Plant of the American Chain Company, Monessen, Pa., has resigned his position. A notable farewell dinner was tendered Mr. Durfee, September 10, by the forty or more superintendents and foremen of the Page Works at which time he was presented with a handsome smoking set in token of the esteem in which he was held. Before actively engaging in business again, Mr. Durfee will take a vacation at his country home near Cleveland.

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A. Clark Moore has resigned as assistant to the president of the Globe Seamless Steel Tube Co., Chicago, with which he has been connected since November, 1919.

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D. D. Lewis has been appointed general manager of the Carroll Foundry & Machine Tool Company, Bucyrus, Ohio. Mr. Lewis began his career in Johnstown, Pa. He grew up in the steel industry and became identified in the building of blast furnaces and rolling mills. He served as general manager of the Southwark Foundry & Machine Co., Philadelphia; was general manager of the Buckeye Engine Company, Salem, Ohio, and prior to that time was identified with the Cambria Steel Company, Johnstown, Pa. He had been employed by the Jones & Laughlin Steel Company, Pittsburgh. Mr. Lewis was affiliated with the late Tom L. Johnson, when he built the Johnson Steel Mill at Lorain, Ohio. In addition to the Johnson Company's plant, Mr. Lewis at one time also was manager of the Algoma Steel Company, Sault Ste. Marie, Ont.

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Harold W. Abbott has resigned as technical supervisor at the Massena plant of the Aluminum Company of America, to accept a similar position with the Stackpole Carbon Company, St. Marys, Pa.

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Dr. F. G. Cottrell, head of the chemical activities of the National Research Council, will sail from France on October 11th on his return to the United States. Dr. Cottrell has spent the summer studying various phases of the chemical industry in Europe. Among other things he paid particular attention to the liquefaction of gases.

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W. G. Jones has been elected vice-president and treasurer of the W. A. Jones Foundry & Machine Company, Chicago, and will continue to serve as general manager.

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N. W. Elmer has opened an office in Quincy, Mass., as consulting engineer in conveying and mechanical handling. Mr. Elmer was formerly engineer for the Harry M. Hope Engineering Company, Boston.

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Paul A. Billings, who recently was made representative of the Falcon Steel Co., Niles, Ohio, has announced establishment of headquarters at 2306 Dime Bank Building, Detroit.

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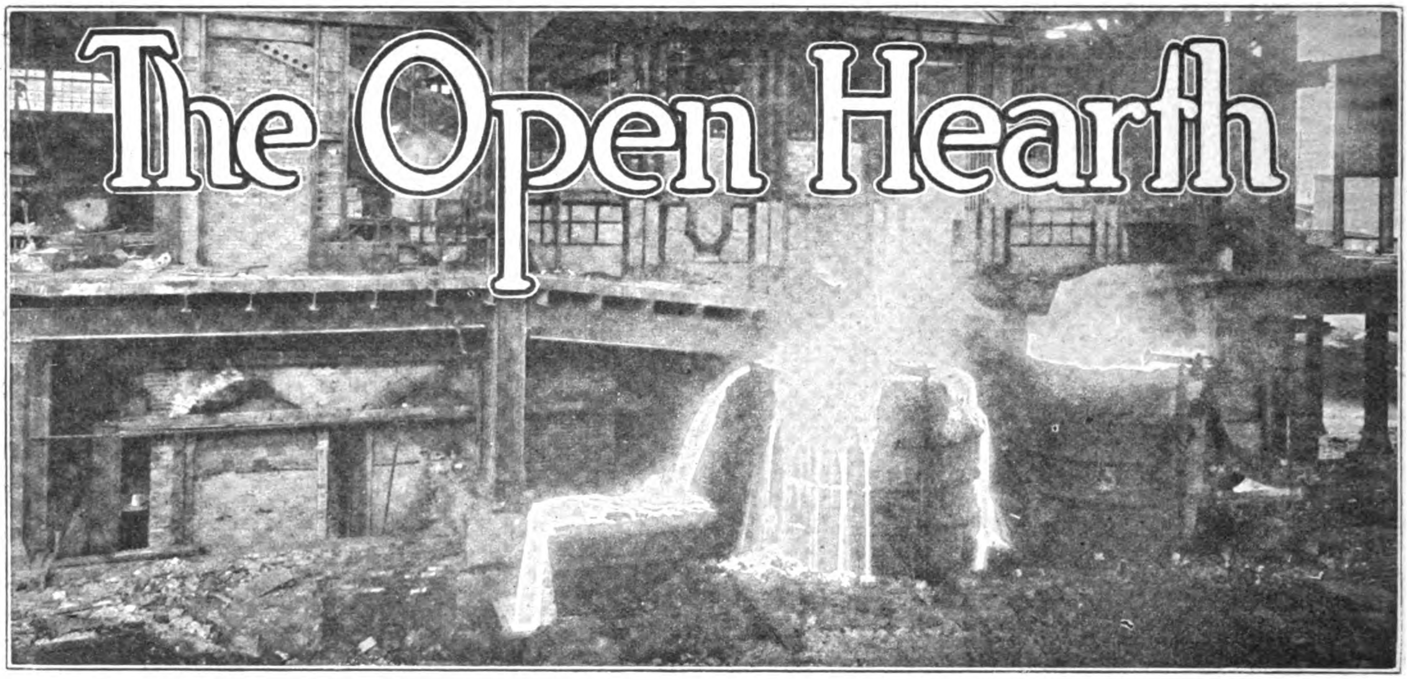
Dr. Raymond F. Bacon has resigned as director of Mellon Institute to take effect January 1, 1922. Dr. E. R. Weidlein has been appointed acting director.



The Open Hearth

Paul Boulanger, a director of Thyssen & Company, Mulheim, Ruhr Region, Germany, is now visiting the United States on a tour of inspection of heavy material handling appliances in use here. Mr. Boulanger recently visited the Farrell Steel Works of the Carnegie Steel Company, at Farrell, Pa., and has also investigated the ore handling machinery at Duluth. His headquarters while in this country are with F. A. Borgemeister, 50 Church Street, N. Y.

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C. C. Hanch, vice-president of the National Automobile Chamber of Commerce and chairman of its taxation committee, soon is to become executive vice-president of the United States Automotive Corporation, subsidiaries of which are the Lexington Motor Company, The Ansted Engineering Company, the Ansted Spring & Axle Company, the Connersville Foundry Corporation, the Fayette Painting & Trimming Company, and the Teetor-Hartley Motor Corp. Frank B. Ansted is president of the corporation. Mr. Hanch, as the executive vice president will have charge of the operating policies of the company, and will have his headquarters at Connersville, Ind., the home office of the United States Automotive Corp. Mr. Hanch had long been connected both with the Nordyke & Marmon Co. and with the Studebaker Corp. Following his connection with these companies, he became chief of the automotive products section of the war industries board. After the close of the war he went to Europe as trade commissioner for the department of commerce, and made an investigation of trade and industrial conditions in England, France, Belgium and Italy. Mr. Hanch will retain his connection with the Homer McKee Company, an advertising company of Indianapolis.

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J. M. Lloyd after serving two and a half years as superintendent of the Lowellville, Ohio, plant of the Sharon Steel Hoop Co., Sharon, Pa. has resigned, effective October 1st.

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Sherwin F. Kelly is in New York, representing the French firm of C. & M. Schlumberger, Prospection Electrique. He intends to study American and Canadian ore deposits, to demonstrate their adaptability to investigate by apparatus developed by Mr. Schlumberger.

H. Voges, Jr., has resigned as vice president and general manager of the Webster & Perks Machine Tool Company, Springfield, Ohio.

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Ross C. Purdy, formerly director of research Norton Company, Worcester, Mass., and for the past two years consulting ceramist at Buffalo and elsewhere, has been made permanent general secretary of the American Ceramic Society, of which he was president in 1909 and 1910.

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Isaac Harter, assistant to the president, Babcock & Wilcox Company, New York, boilers, stokers, etc., has been appointed general superintendent of the company.

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R. H. Mickey, who for several years represented the service department, Pittsburgh plant, Heppenstall Forge & Knife Co., has accepted a position as drop forge superintendent with the Eureka Company, North East, Pennsylvania. The Eureka Company manufacturers electrical supplies and also makes a complete line of small drop forgings.

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Bradley Stoughton, Engineering Societies' Building, 29 West Thirty-ninth street, New York, having resigned after more than eight years as secretary of the American Institute of Mining and Metallurgical Engineers will resume his practice as a consulting engineer, making a specialty of financial investigations and reports to bankers, investors, directors, and examining accountants on industrial plants, engineering enterprises, iron and steel plants, etc.

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William S. Knudsen, for 10 years associated with the Ford Motor Company and responsible in a large measure for its production efficiency, resigned from the Ford organization to become associated with Ireland & Matthews as general manager. Previous to joining the Ford organization he had years of experience in various capacities in the metal stamping industry. Production is running among the highest of Detroit industrial concerns.

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Dr. Richard Moldenke, last week was a guest at luncheon of the Worcester, Mass., members of the New England Foundrymen's Association, that city. H. P. Blumenauer, general manager Arcade Malleable Iron Company, presided. Dr. Moldenke spoke on foundry costs and on his observation of conditions in Europe, gathered during a trip from which he recently returned.

Some Pointers on By-Product Coke Oven Operations

COKE OVEN GAS FOR THE OPEN HEARTH.

The Journal of the West of Scotland Iron and Steel Institute recently published impressions of American steel mill practice which were gained by R. Percival Smith of the Lanarkshire Steel Company, Ltd., during a recent visit to the United States. An abstract of a paper read before the June meting of this society is as follows:

As you all know, producer gas is not used exclusively in America, nor yet to a preponderating degree, in open-hearth furnaces. They have a variety of fuels. At the top of the list stands natural gas. It is considered the best fuel of all, but its uses are now restricted. In having supplies of this gas America was richly blessed. Having come into such wealth without a struggle, the American failed, however, to appreciate it fully and squandered it. It is now available for melting purposes in a few places only, and in these cases provision is made for its immediate discontinuance. The American regrets its passing. Coke oven gas is employed largely. Its constitution and heating value is exemplified by the following analysis from the coke oven plant at Clairton, the most modern of its kind in the United States:

Carbon dioxide	1.65 per cent
Carbon monoxide	3.93 per cent
Illuminants	3.32 per cent
Carbohydrates	33.53 per cent
Hydrogen	54.11 per cent
Nitrogen	3.46 per cent
Btu.	578
Sulphur, per 100 cu. ft. of gas	0.0606 lb.

Coke oven gas is very light, and consequently difficult to control. As far as my experience goes, only one firm in America uses it alone successfully; in all other cases that came under my notice tar was used with it, the tar being introduced above the gas by means of a small nozzle after passing through a special form of carbureter. Tar by itself is highly favored, in spite of certain drawbacks. Carburetion does not yet appear to have reached perfection, a black heart being very noticeable in the flame. The checkers soon become very dirty, and have to be cleaned out after a run which never seems to exceed 200 charges. The heating valve of tar as fuel for open-hearth furnaces is, however, undoubted as long as the system is in good condition, and the speed with which a furnace thus heated melts and works a charge must be considered quite satisfactory. The amount of tar used per ton varies between 30 and 40 gal. Each gallon contains about 155,000 Btu., of which, therefore, 4,650,000 to 6,200,000 are expended in the manufacture of one ingot ton. If you express the results obtained with producer gas in the same terms, you will find that tar compares very favorably indeed with it.

COKING STUDIES AT OHIO STATE UNIVERSITY

The department of metallurgy of the Ohio State University, under the auspices of and with the funds provided by the Engineering Experiment Station of the university, has installed a full scale 1-ton vertical coal retort, a complete byproduct recovery system equipped with gas meters, pyrometers and recording calorimeters. With this equipment the entire coal resources of Ohio are being surveyed with the view of obtaining accurate information concerning the possibilities of utilization of Ohio coals for gas making, byproduct recovery and coke production. Five-ton samples of each coal to be tested are obtained, duplicate 1-ton samples of this are carbonized under ordinary vertical retort conditions, the tar, ammonia and light oil recovered and analyzed, and the coke made is obtained and its quality determined by chemical analyses and physical tests. The gas made is measured in a recording and integrating Bailey gas meter and its heat value recorded in a continuous recording Smith gas calorimeter. Also a sufficient amount of each coal is crushed, sized, the coarser sizes jigged and the finer sizes tabled on a Wilfley table. The clean coal is then dried and retorted. In this way it is expected that the most complete information possible will be obtained on all of the Ohio coals. Tests will also be made on mixtures of Ohio coals with coals from other states. It is hoped to get all this information so that the cities of the state can mak the most intelligent selection of coals for the production of artificial gas to supplement the waning natural gas supply.

SOUTH AMERICAN BUSINESS SLOW.

W. C. Downs, general representative of the United States Steel Products Company, returned on the Hanson liner "Huron" from a business trip in South America. He reports that the steel business in Brazil has been for some time at an absolute standstill.

"There are large stocks of steel and steel products piled up in the ports," says Mr. Downs, "but the channels of distribution seem to be clogged. Business men expect that the movement of goods may be resumed at almost any time, but definite predictions cannot be made. However, there is no doubt that when activity is renewed a large volume of business will be created. The German sales agents are quoting very low prices on steel products, but even at that they are not doing any business because stagnation is general.

"When trade is resumed the United States should be in a favorable position to compete with European industries, as one of the great essentials—transportation—has been tremendously improved between this country and South America in the last few years. Prompt deliveries are now possible owing to the increased number of vessels in the Munson Lines and to the faster trips being made by the new ships."

STATEMENT OF OWNERSHIP, MANAGEMENT, ETC., OF

The Blast Furnace and Steel Plant

[Required by Act of Congress of August 24, 1912]

Name of Publication: **The Blast Furnace and Steel Plant**, published monthly at Pittsburgh, Pa. [Report for October 1, 1921.]

Publisher—The Andreson Co., Inc., 108 Smithfield St., Pittsburgh, Pa.

Editor—D. N. Watkins, 108 Smithfield street, Pittsburgh, Pa.

Managing Editor—F. C. Andresen, 108 Smithfield street, Pittsburgh, Pa.

Business Manager—F. C. Andresen, 108 Smithfield street, Pittsburgh, Pa.

(Names and addresses of stockholders holding 1 per cent or more of total amount of stock:

Estate of H. A. Andresen, care Colonial Trust Co., Pittsburgh, Pa.
F. C. Andresen, 108 Smithfield street, Pittsburgh, Pa.
L. L. Carson, 108 Smithfield street, Pittsburgh, Pa.
R. H. Thiess, 108 Smithfield street, Pittsburgh, Pa.
M. M. Zeder, 108 Smithfield street, Pittsburgh, Pa.

Known bondholders, mortgagees, and other security holders holding 1 per cent or more of total amount of bonds, mortgages, or other securities: None.

F. C. ANDRESEN, Business Manager.

Sworn to and subscribed before me this 28th day of September, 1921.

JOHN N. ENGLISH, Notary Public.

(My commission expires March 9, 1923.)

TRADE NOTES

F. J. Ryan & Company, Industrial Furnace Builders, Wesley Building, Philadelphia, Pa., announce the establishment of three additional agencies. They are as follows:

Detroit under the direction of Mr. David P. Harr, 423 Depot St., Latrobe, Penna., who will also cover the Cleveland and Toledo districts. Chicago, under the direction of the Singer Kennedy Construction Co., 39 W. Adams St., Chicago, Ill., who will cover the Middle West. Mr. L H. Chamberlain, 72 New Montgomery Ave., San Francisco, Cal., who will cover the Pacific coast. F. J. Ryan and Company have recently moved their general offices and sales from the Franklin Trust Building, to larger quarters in the Wesley Building, 17th and the Parkway, Philadelphia. We also announce the removal of our Engineering Departments to Lancaster, Penna., where they will be established in the headquarters of the Lancaster Iron Works, with whom F. J. Ryan and Company become associated in the early part of the present year.

Harry W. Eastwood, who for the past four years has had charge of the Steel Mill and Crane Division of the Cutler-Hammer Mfg. Co., Cleveland Branch, has been made Branch Manager, taking the place of Lynn B. Timmerman, former Asst. Manager, Central District, who leaves to enter the automobile business in Lima, Ohio, after having been associated with the Cutler-Hammer Cleveland Office since 1914. Associated with Mr. Eastwood will be E. L. Windenburg, as Office Manager. Mr. Windenburg takes the vacancy made by the sudden death of Mr. A. F. Loomis on August 22. The Cleveland Office and territory of the Cutler-Hammer continues as a part of the Central District, comprising the Pittsburgh and Cincinnati Offices and territory.

Earl F. Heimpel, M. E., formerly Chief Engineer of the Edison Portland Cement Co., Stewartsville, N. J., has resigned to enter the sales force of the M. J. Dougherty Co., Piping Fabricators and Engineers of Philadelphia. Mr. Heimple who is a graduate of Lehigh University has had a wide and varied experience in the engineering field and will be located in the home office.

The A. P. Swoyer Co. merchandise stock at 17 North 7th Street, Philadelphia, has been purchased and the premises formerly occupied by Swoyer leased to U. T. Hungerford Brass & Copper Co. The Elcon Engineering Co. opened offices in Columbus, O., to engage in general contracting and engineering, specializing in elevating and conveying equipment.

A new corporation known as the G. F. Wright Steel & Wire Co. has been organized at Worcester, Mass, headed by George F. Wright, son of George M. Wright, former president of the Wright Wire Co., and it has purchased the plant of the Standard Plunger Elevator Co. at Jamesville, a suburb of Worcester. The new company will manufacture wire rope, wire cloth, wire lathing and poultry netting. Some of the special machinery has already been constructed, and it is planned to begin manufacturing at an easly date.

The Gasoline Recovery Corp., New York, announces that a commercial natural gas gasoline plant operating according to the Burrell-Oberfell charcoal process is in operation at Bradford, Pa. The plant has a capacity of 900 gal. per day. It is also announced that the charcoal gasoline plant of the Monroe-Louisiana Carbon Co., located at Monroe, La., is nearing completion.

The Schaffer Engineering & Equipment Co., Pittsburgh, Pa., announces the combining of the administrative, sales and manufacturing departments in its new general offices at 2828 Smallman St., Pittsburgh, Pa.

The Cochrane Steam Specialty Co. of Massachusetts has been organized to represent in New England a number of well-known manufacturers of power-plant equipment, including the H. S. B. W.-Cochrane Corp., manufacturer of feed water heaters, steam and oil separators, V-notch meters and metering heaters, hot and cold process softeners, flow meters, precision meters, weighing meters, multiport valves and multiport drainers, also the Steam Motors Co., Inc., manufacturer of steam turbines for driving generators, pumps, fans, etc., and the D. Connelly Boiler Co., builder of water tube steam boilers. The office at 1045 Oliver Bldg., Boston, Mass., is in charge of Elliott Greene.

The Link-Belt Co., Chicago, has acquired all of the capital stock of the H. W. Caldwell & Son Co., and Frank C. Caldwell has been elected a director of the Link-Belt Co. The H. W. Caldwell & Son Co.'s plant will continue to operate under separate corporate existence under its present name.

The Sullivan Machinery Co., Chicago, Ill., has moved its Cleveland office from 810 Park Bldg., to Room 824, Kirby Bldg. Ralph T. Stone is manager. It is also announced that a supply depot and service station for coal-mining machinery, supplies and repair parts has been opened at Seventh Avenue and Thirteenth Street, Terre Haute, Ind. H. T. Wiley is in charge.

Charles Cory & Son, Inc., 183-187 Varick St., New York City, has obtained the manufacturing and selling rights for the Royer line of portable and stationary flow indicators. These indicators are designed for indicating the flow of all kinds of corrosive and non-corrosive gases, vapors and liquids and were formerly manufactured and sold by the A. H. Sloan Co. of Detroit, Mich. It is intended, through the increased manufacturing facilities provided by the Cory Company, to increase the production of these meters and make further extensions to the Royer line.

TRADE PUBLICATIONS

"Wheeler Condensers" is the title of the new general catalogue issued by the Wheeler Condenser & Engineering Company, Carteret, N. J., which illustrates and describes a complete line of condensers and accessories for stationary and marine service—including Wheeler condensers, vacuum pumps, centrifugal pumps, cooling towers, condenser tubes, feed water heaters, etc., Many of the designs described are of special interest to power plant engineers, since they represent most recent engineering improvement. Among them are: a new design of a 26-inch vacuum surface condensing equipment adapted for engine work and dispensing with combined auxiliary pumps; the Wheeler steam jet air pump with combined inter-condenser and heater operating at maximum efficiency without complicated and expensive accessories; the Wheeler jet condenser with expansion joint between condenser body and a turbine and a centrifugal removal pump having a special vertically split casing. In a section devoted to Crescent Brand condenser tubes, the precision that enters into each step of the manufacture of the highest quality tubes is explained. A condenser data sheet is included with each copy.

The Ashland Fire Brick Co., Ashland, Ky., has published an 8-page illustrated bulletin entitled, "Fire Brick for Rotary Cement Kilns." The booklet contains a short resume of conditions to which various types of fire brick are adapted.

W. S. Rockwell Company have issued Bulletin No. 232—"The Variety of Furnace Design", which is the third of the series dealing with fundamentals that influence the quality and cost of heated products. It illustrates the relation of type and arrangement of heating equipment to cost of production, and the many factors that must be considered in adapting such equipment to individual manufacturing conditions.

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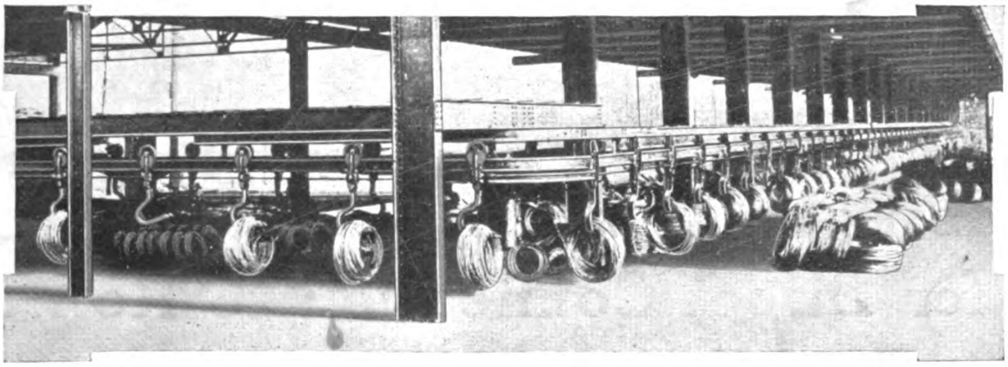
The Blast Furnace and Steel Plant

Pittsburgh, October, 1921.

MORGAN OF WORCESTER
CONTINUOUS ROLLING MILLS



A Recent Production Record
Made on a Morgan Double Strand
Continuous Rod Mill
in 14 Days of Operation

Total Production of #5 Rod	5562.5 GROSS TONS
Number of 12 hour turns the mill operated	24.33
Average production per 12 hour turn	228.62 GROSS TONS
Maximum production per 12 hour turn	242 GROSS TONS
Average Yield	97.4 %

MORGAN CONSTRUCTION CO.
WORCESTER, MASS. U.S.A.